CHAPTER

6

Industrial Conservation Program

6.1 INTRODUCTION

This chapter contains the Arizona Department of Water Resources' (Department) conservation program for industrial users within the Tucson Active Management Area (AMA). The purpose of the Industrial Conservation Program is to move industrial water users within the AMA to the greatest level of efficiency economically attainable given use of the latest available water conservation technology. In addition to conservation, the replacement of groundwater sources with renewable water supplies during the third management period will ensure that industrial users make effective strides toward contributing to the AMA's statutorily mandated goal of safe-yield by the year 2025.

The Groundwater Code (Code) defines industrial use of water as "a non-irrigation use of water not supplied by a city, town, or private water company, including animal industry use and expanded animal industry use." A.R.S. § 45-561(5). An industrial user is a person who uses groundwater for an industrial use. In most cases industrial users withdraw groundwater from their own wells pursuant to Type 1 or Type 2 non-irrigation grandfathered rights or a groundwater withdrawal permit. These rights and permits (collectively referred to in this chapter as "industrial rights") have annual volumetric groundwater allotments. The total volume of Type 2 rights in the AMA was set at the time the Code was enacted. The total volume of water associated with Type 1 rights can increase over time as agricultural land with irrigation grandfathered rights is retired from production and the rights are converted to Type 1 non-irrigation grandfathered rights. General Industrial Use (GIU) permits are issued by the Department if water service cannot be secured from a municipal provider and if the use of surface water or effluent, or the purchase or lease of a grandfathered groundwater right, is not economically feasible. Permits expire after a specified period of years. (See the Glossary of Terms for a description of water rights and permits.)

An industrial user may also receive groundwater from an irrigation district. However, an industrial user may not receive groundwater from an irrigation district in excess of the amount it was entitled to receive on June 12, 1980 unless it has obtained a grandfathered right or a GIU permit. A.R.S. § 45-497(B).

There are also types of groundwater users that, although served by a municipal water provider, are subject to industrial program conservation requirements through the Municipal Conservation Program. These users include turf-related facilities and large-scale cooling facilities, and are referred to in the Municipal Conservation Program as "individual users."

Conservation is an important tool for reaching the AMA safe-yield goal. Industrial facilities generally use water efficiently due to pumping costs and industrial discharge limitations that require them to recycle water and contain water on-site. The allotment-based conservation requirements for the turf industry have required turf-related facilities to comply with declining application rates per acre since the First Management Plan became effective. This program has resulted in significant conservation savings through efficient use of water.

Industrial users have the legal authority to withdraw groundwater up to the annual allotment of their rights or permits subject to management plan conservation requirements. Because the cost of pumping groundwater is relatively low compared to the cost of other sources of water, there is no economic incentive for industrial users to switch to renewable water supplies. Because the Department does not have the authority to require holders of industrial rights to use renewable supplies in place of groundwater, it has tried to develop meaningful incentives to encourage use of renewable supplies.

Some industrial users use surface water, effluent, or industrial wastewater. However, the majority of industrial water use is groundwater. The industrial sector uses a smaller volume of renewable water supplies than either the agricultural or municipal sector. The industrial sector's contribution to safe-yield is therefore relatively small. The only industrial facilities that use effluent are turf-related facilities.

However, almost all of this use is by individual users, not industrial right holders. Industrial right holders used 782 acre-feet of effluent in 1995, while individual users used over 5,800 acre-feet.

Users in several industrial categories have indicated that they may be interested in using renewable water supplies if such supplies were available and comparable in cost to groundwater. However, there are many factors that impede the ability of industrial users to use renewable water supplies, including lack of proximity to renewable supplies, reliability, cost, supply ownership, and water quality issues. While there are no significant water quality problems associated with using effluent on turf-related facilities, use of this source by other industrial users could require additional treatment to remove salts and other constituents.

In all the AMAs, significant amounts of industrial right allocations are unused. These unused allocations represent a potential increase in groundwater pumpage allowable under statute and provide a means for the industrial sector to expand over time.

For the third management period, there are general conservation requirements that apply to all industrial users. In addition to these requirements, there are specific conservation requirements that apply to the following industrial users in the Tucson AMA:

- Turf-Related Facilities ($\geq$10 acres)
- Sand and Gravel Facilities (>100 acre-feet/year)
- Metal Mining Facilities (>500 acre-feet/year)
- Large-Scale Power Plants (>25 megawatts)
- Large-Scale Cooling Facilities (>1,000 tons)
- Dairy Operations (monthly average $\geq$100 lactating cows/day)
- New Large Landscape Users (>10,000 square feet of water intensive landscape)
- New Large Industrial Users (>100 acre-feet/year)

Industrial uses of groundwater in the Tucson AMA consist primarily of industrial processing, cooling, and landscape watering. Industrial demand as a percentage of overall water use is higher in the Tucson AMA than in any other AMA due to metal mining operations. Industrial users with groundwater rights or permits accounted for almost 20 percent of the AMA water use in 1995, or about 60,000 acre-feet. Water use by industrial users is projected to increase to approximately 75,000 acre-feet by 2025. About 6 percent of this demand is anticipated to be met by effluent as compared to about 1 percent in 1995.

This chapter is organized as shown below. Following the Introduction, each Industrial Conservation Program is discussed under a separate subsection. In general, each of the subsections contain all or some of the following: (1) an introduction, (2) water use by the subsector, (3) First and Second Management Plan program development, (4) issues and Third Management Plan development, (5) program description, (6) non-regulatory efforts, (7) future directions, and (8) subsector conservation requirements.

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6.1.1 Statutory Provisions

6.1.1.1 Conservation Requirements

The Code requires that the management plan contain a conservation program for industrial users. For the third management period the director is required to establish for each plan:

> additional conservation requirements for all non-irrigation uses of groundwater to be achieved by the end of the third management period and may establish intermediate conservation requirements to be achieved at specified intervals during the third management period. . . . For industrial uses including industrial uses within the exterior boundaries of the service area of a city, town, private water company or irrigation district, the program in each plan shall require the use of or establish conservation requirements based on the use of the latest commercially available conservation technology consistent with reasonable economic return. A.R.S. § 45-566(A)(2).

6.1.1.2 Individual User Requirements

The Code also requires the establishment of additional conservation requirements for municipal uses in the Third Management Plan including "use of such other conservation measures as may be appropriate for individual users." A.R.S.§ 45-566(A)(2). (See Chapter 5). In the First Management Plan, only turf-related facilities receiving water from municipal providers were regulated as individual users. These facilities were subject to the requirements of the Industrial Program as if they were industrial users. Thus, regardless of the source of water, whether from a municipal provider or from the facility's own wells, all turf-related facilities were subject to the turf-related facility conservation requirements in the Industrial Program chapter of the First Management Plan.

Similarly, in the Second Management Plan, turf-related facilities receiving water from a municipal provider were regulated as individual users and were subject to the Second Management Plan's industrial program conservation requirements for turf-related facilities. In addition, new large cooling users, which are typically served by water providers, were also regulated as individual users in the Second Management Plan. These facilities were required to comply with the conservation requirements established for new large cooling users in the Industrial Program chapter.

6.1.2 Industrial Program Development

The Industrial Conservation Program has evolved into a more technically sophisticated program since the First Management Plan. This has been the result of considerable input and cooperation by the regulated community, as well as investigative efforts by the Department.

The First Management Plan requirements stressed water use efficiency and contained other general requirements. There were specific conservation programs only for metal mines, turf-related facilities, electric power plants, sand and gravel facilities, and other industrial users. As a result of consultant studies done for the Second Management Plan, additional conservation requirements were added for new large-scale cooling users, dairies, cattle feedlots, new large industrial users, and new large landscape users. In addition, there was a more specific effluent incentive provision for turf-related facilities.

Development of the Third Management Plan conservation requirements included extensive participation by a wide cross-section of industry representatives, including facility managers, consultants, municipal

representatives, vendors, land developers, and academic research specialists. The following Technical Advisory Committees (TACs) were formed for the development of specific conservation requirements found in the Industrial Conservation Program:

- Turf-related facilities (separate committees for the Tucson and Phoenix AMAs);
- Dairies/feedlots (a joint committee for the Tucson, Phoenix, and Pinal AMAs);
- Large-scale power plants and cooling facilities (a joint committee for the Tucson and Phoenix AMAs);
- Sand and gravel facilities (a joint committee for the Tucson, Phoenix, and Pinal AMAs); and
- Metal mining facilities (Tucson AMA only).

Collectively, over 30 meetings were held with the committees over a one and one-half year period. Committee members had an opportunity to help formulate and suggest conservation requirement alternatives, provide industry expertise, and review final programs.

In the Third Management Plan, separate industrial program categories have been created for large-scale cooling facilities, new large landscape users, and new large industrial user subsectors. These three industrial water use groups were included in the "all industrial users" category in the Second Management Plan, but have been separated out to more clearly present the water use characteristics and specific conservation requirements for the third management period. This results in a total of eight industrial program subsectors in the Third Management Plan for the Tucson AMA: (1) turf-related facilities, (2) large-scale cooling facilities, (3) large-scale power plants, (4) sand and gravel facilities, (5) metal mining facilities, (6) dairy operations, (7) new large landscape users, and (8) new large industrial users. There are industrial users in all of these categories in the Tucson AMA except for new large landscape users and new large industrial users. Some AMA management plans have a conservation program for cattle feedlot operations that have an average of 100 or more beef cattle per day. If a facility meeting this definition should be constructed in the Tucson AMA during the third management period, the management plan may be modified to include the cattle feedlot conservation program.

Industrial subsector requirements vary from allotment-based requirements to the implementation of specific conservation measures. In all cases, the requirements have been developed consistent with the statutory requirement to establish conservation requirements that require the use of, or are based on the use of, "the latest commercially available conservation technology consistent with reasonable economic return." A.R.S. § 45-566(A)(2).

For the Third Management Plan, the Department reviewed the existing subsector programs and tried to address any existing problems or deficiencies. In most instances, specific conservation requirements for the third management period are not significantly different from those in the Second Management Plan. Conservation requirements in the First and Second Management Plans have been effective in improving water use efficiency for certain industrial subsectors. In the Third Management Plan, a number of technical corrections have been made, requirements have been added, additional program alternatives have been included, and renewable supply use incentives have been added or adjusted to be more effective. The specific changes, issues, and renewable supply incentives that were considered in subsector program development are discussed in the subsector sections of this chapter.

6.1.3 Industrial Program Issues

The Department considered a number of issues associated with the Industrial Program as it developed the Third Management Plan. Several issues emerged that have long-term implications for industrial water use. Some issues can be addressed using existing statutory and regulatory mechanisms while others may require a statutory amendment. The Department will continue to pursue opportunities to address these issues.

6.1.3.1 Use of Renewable Supplies by Industrial Users

Use of renewable supplies by industrial users in the Tucson AMA is limited by physical, economic, and legal barriers. Physical access to renewable supplies is frequently limited because potential users are often far removed from Central Arizona Project (CAP) and effluent conveyance facilities. The cost of constructing delivery systems to the industrial users may be prohibitive. Because industrial users have legal authority to withdraw groundwater from their own wells at a cost consisting primarily of relatively low energy costs, there is no economic incentive to incur the additional expenses associated with the purchase, delivery, and possible treatment of an alternative supply. In addition, water quality regulations, such as wastewater reuse rules or aquifer protection permit rules, may also provide impediments to the use of CAP water or effluent by industrial users.

No industrial user in the Tucson AMA holds a CAP subcontract. Further, effluent supplies in the AMA are primarily controlled by the City of Tucson and Pima County. Thus, industrial users would need to enter contractual relationships with Central Arizona Water Conservation District, Tucson, or Pima County to obtain the legal right to use these supplies.

6.1.3.2 Matching Water Quality and Uses

Each industrial user category has its own water quality requirements related to the particular product or process involved. Although some users may require high quality water, others do not. For example, turf facilities are able to use effluent without any significant adverse impact and sand and gravel facilities can use effluent for aggregate washing. Remediated groundwater may be acceptable for certain industrial uses. One turf-related facility in the Tucson AMA uses groundwater that contains nitrate above the maximum contaminate level for drinking water. Use of industrial wastewater may also be a potential water supply and needs to be investigated. Constraints on use include location of the supply in relation to the facility, cost and pre-treatment needs.

In 1997, the Legislature enacted legislation significantly revising the Water Quality Assurance Revolving Fund (WQARF) program to provide incentives for the use of remediated groundwater to facilitate the treatment of contaminated groundwater. Among other things, the WQARF legislation provides that when determining compliance with management plan conservation requirements, the Department shall account for groundwater withdrawn pursuant to approved remedial action projects under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, consistent with the accounting for surface water. Laws 1997, Ch. 287, § 51(B). See Chapter 7, section 7.4.4.6.3. Groundwater withdrawn pursuant to an approved remedial action project retains its legal character as groundwater for all other purposes under Title 45, Arizona Revised Statutes, including all other laws regulating groundwater withdrawal and use such as the assessment of withdrawal fees pursuant to A.R.S. § 45-611 *et seq.*, as well as laws regulating water exchanges as set forth in A.R.S. § 45-1001 *et seq.*, the transportation of groundwater as set forth in A.R.S. § 45-541 *et seq.*, withdrawals of groundwater for transportation to active management areas as set forth in A.R.S. § 45-551 *et seq.*, and underground water storage, savings, and replenishment as set forth in Title 45, Chapter 3.1, Arizona Revised Statutes.

For each approved remedial action project, the annual amount of groundwater that is eligible for the remediated groundwater accounting incentive is the maximum annual volume of groundwater that may be withdrawn pursuant to the project, as specified in the consent decree or other document approved by the EPA or ADEQ. However, if the project was approved prior to June 15, 1999 and the maximum annual volume of groundwater that may be withdrawn pursuant to the project is not specified in a consent decree or other document approved by the EPA or ADEQ, the annual amount of groundwater that is eligible for the remediated groundwater accounting incentive is the highest annual use of groundwater withdrawn pursuant to the project prior to January 1, 1999. The director may modify the annual amount of groundwater that is eligible for the accounting incentive if an increase in withdrawals is necessary to

further the purpose of the project or if a change is made to the consent decree or other document approved by the EPA or ADEQ.

In order to qualify for the remediated groundwater accounting incentive, a person must notify the director in writing of the anticipated withdrawal of the groundwater prior to its withdrawal. The notification must include a copy of a document approved by ADEQ or the EPA such as the Remedial Action Plan (RAP), Record of Decision (ROD) or consent decree. Unless specified in the document, the notification must include the volume of groundwater that will be pumped annually pursuant to the project, the time period to which the document applies, and the annual authorized volume of groundwater that may be withdrawn pursuant to the project. The notification must also include the purpose for which the remediated groundwater will be used and the name and telephone number of a contact person. Additionally, at the time the notice is given, the person must be using remediated groundwater pursuant to the approved remedial action or must have agreed to do so through a consent decree or other document approved by ADEQ or the EPA. Remediated groundwater that qualifies for the accounting must be metered and reported separately from groundwater that does not qualify for the accounting. (See section 6-204 of the Conservation Requirements for All Industrial Users).

6.1.3.3 Unused Allotment

There is a large volume of unused groundwater right and permit allocations associated with the industrial sector. Rights and permits held by industrial users total nearly 193,000 acre-feet. In 1995, the unused portion was more than 132,000 acre-feet. This volume is slightly less than the estimated net natural and incidental recharge volume for the Tucson AMA. Some of the unused allotment may never actually be put to use and use predictions are difficult. However, industrial use is projected to be 73,300 acre-feet in 2010 and 75,400 acre-feet in 2025. If the entire unused allotment volume were pumped, it would be a serious hindrance to reaching safe-yield unless it were offset through replenishment with imported renewable supplies. Type 1 grandfathered rights and some Type 2 grandfathered rights may be extinguished for assured water supply credits (mineral extraction and electric power Type 2 rights may not be extinguished for this purpose). This mechanism provides an opportunity to permanently extinguish existing industrial rights.

6.1.3.4 General Industrial Use and Mineral Extraction Permits

GIU permits are issued under A.R.S.§ 45-515 for industrial uses located outside of water provider service area boundaries pursuant to certain conditions and are valid for a specified period of time. Permits may also be issued for mineral extraction and metallurgical processing under A.R.S. § 45-514. These permits allow groundwater pumping in addition to withdrawals pursuant to existing industrial rights. The total permitted GIU volume in the Tucson AMA in 1995 was 2,176 acre-feet, although the amount used was only 473 acre-feet. The number of permit applications may increase in the future as the availability of Type 2 grandfathered rights to serve industrial uses becomes more limited.

6.1.4 Non-Regulatory Efforts

During the first half of the second management period, over $106,000 in grant money was awarded to benefit industrial users in the Tucson AMA under the Department's Conservation Assistance Grant Program. Grants were awarded for research and education on turf water demand and management, evaluation of the conservation potential of metal mines, and development of a training program for water efficient cooling tower management. The Department is committed to continuing its effort to assist regulated industrial users in meeting their conservation requirements through direct staff assistance and through the grants program during the third management period. This effort could be in the form of technical assistance or the granting of monies to fund research on new water conservation technologies.

6.1.5 Future Directions

Maintaining water use efficiency, providing conservation and technical assistance, and developing opportunities for renewable resource use are the most likely future directions for the industrial sector. The future of industrial users in relation to the safe-yield goal is largely shaped by the potential for growth in groundwater use and existing constraints on replacing groundwater use with renewable supplies.

In order for the industrial sector to contribute more to the achievement of the AMA goal, there must be continuing and enhanced water use efficiency, meaningful incentives for the use of renewable water supplies, and viable administrative and physical renewable resource use mechanisms in place. The majority of effluent use in the third management period is projected to be used by municipally-served turf facilities through the Tucson Water regional reclaimed system. However, there may be potential for CAP and effluent use by sand and gravel facilities and CAP use by metal mines or other facilities in the future. In order for this to occur, there must be either regional infrastructure cost sharing opportunities for direct use that make it economically viable to use a renewable supply or low cost replenishment mechanisms whereby pumped groundwater would be replenished by a renewable supply elsewhere in the AMA under certain conditions.

Apart from the groundwater right retirement provision in the Code and the groundwater right extinguishment provisions in the Assured Water Supply Rules (AWS Rules), there is currently no regulatory authority that could reduce grandfathered groundwater rights. The Department has decided not to include a grandfathered right purchase and retirement program in the Third Management Plan at this time. The extent to which the extinguishment provisions in the AWS Rules will limit industrial use is impossible to predict. It may be necessary to explore groundwater replenishment approaches to offset a portion of industrial pumpage. Expanding the authority of the Central Arizona Groundwater Replenishment District (CAGRD) to recharge excess CAP water outside of the Assured Water Supply Program or establishing a separate replenishment authority for industrial users are possible mechanisms. Statutory change would be necessary to implement either mechanism.

The development of "critical area" programs within the AMAs will be a major focus of the Department's activities during the third management period. This may involve the development of water management strategies to address localized water conditions, promoting withdrawals in areas experiencing groundwater recharge and restricting withdrawals from areas experiencing severe declines. For industrial uses this could mean limiting new General Industrial Use permits and industrial users in critical areas, limiting Type 1 non-irrigation grandfathered right conversions or buying out or providing incentives for extinguishing existing grandfathered rights in specified areas.

Industrial water uses may change as new technologies are developed. Research may need to be conducted during the third management period to investigate water conserving opportunities associated with use of these technologies by certain industrial users. This research could be used to develop conservation requirements for the Fourth Management Plan.

6.2 ALL INDUSTRIAL USERS

6.2.1 Introduction

The conservation requirements in this section apply to all industrial water users. In addition to these requirements, certain industrial users are also required to comply with conservation requirements specific to their type of water use under other sections of this chapter. For example, a sand and gravel facility must comply with the requirement in this section to use low-flow plumbing devices at the facility to the maximum extent possible and, in addition, must comply with the conservation requirements in section 6.4.6 of this chapter.

The following industrial users are required to comply with the conservation requirements for all industrial users in this section, as well as conservation requirements for their specific type of water use in other sections of this chapter: turf-related facilities, sand and gravel facilities, metal mining facilities, large-scale power plants, large-scale cooling facilities, dairy operations, new large landscape users, and new large industrial users. All remaining industrial users are referred to in this section as "other industrial users" and are required to comply only with the conservation requirements for all industrial users in this section.

6.2.2 Water Use by "Other Industrial Users"

"Other industrial users" in the Tucson AMA used approximately 4,000 acre-feet of groundwater in 1995, which accounted for about 7 percent of the total industrial groundwater withdrawals in the AMA in that year. Of this amount, approximately 2,800 acre-feet was used by seven "large" users (more than 100 acre-feet per year). Many different types of commercial and manufacturing uses are included in this category. Some of the largest users include aerospace facilities, cement manufacturing plants, electronics plants, hospitals, bottling plants, shopping centers, and resorts. Water uses commonly include cooling, landscaping, sanitary, kitchen and industrial process uses.

There are about 400 water rights and permits associated with the "other industrial user" category in the Tucson AMA. The total annual groundwater right allotment associated with these rights is almost 91,000 acre-feet. Of that amount, over 52,000 acre-feet is held by the City of Tucson. An additional 14,000 acre-feet is associated with retired farmland in the Green Valley/Canoa Ranch area. Raytheon Aircraft holds over 17,000 acre-feet of allotment from rights and permits that are used to withdraw and treat contaminated groundwater.

The large volume of rights held by the City of Tucson will likely be used for municipal supply purposes in the future and not for industrial use. Similarly, the Green Valley area rights will likely be used for residential development purposes, although a substantial volume may be used for turf-related watering. It is anticipated that most future industrial development will be served by municipal providers because commercial and industrial development usually occurs within their service areas.

6.2.3 Program Development and Issues

In the First Management Plan, "other industrial users" were required to avoid waste and make efforts to recycle water. In addition, they were prohibited from using single-pass cooling or heating. These requirements and others were also included in the Second Management Plan for all industrial users.

Consultant studies done in preparation of the Second Management Plan investigated water use associated with landscaping, heating and cooling, and sanitary and kitchen water use practices. These studies identified areas of water conservation potential and appropriate water conservation techniques. The Department has determined that the findings from these studies still apply to current industrial use and practices. In addition, a 1996-97 Tucson AMA study, funded by a Department conservation assistance

grant, investigated water use practices at cooling towers and yielded additional information on water conservation potential for cooling towers.

The following techniques are recommended for achieving water conservation in the industrial sector:

- reusing or recycling water
- avoiding single-pass cooling unless the water is reused
- use of low flow plumbing fixtures
- use of low water use landscaping with efficient irrigation systems
- developing site-specific water conservation plans for large facilities

Most of these techniques are included in the conservation requirements for all industrial users detailed in section 6.2.5 and apply to "other industrial users" as well as industrial users subject to conservation requirements for their specific type of water use. The Third Management Plan requirements are intended to send a strong conservation message to all industrial users to use water efficiently.

The Department also inventoried the "other industrial user" category during the planning process for the Third Management Plan to determine if there were any user groups with sufficient usage and conservation potential to warrant specific conservation requirements. The diverse nature of water uses within this category make it difficult to formulate volumetric conservation requirements that address the various types of industries. There are, however, some opportunities for water conservation.

The greatest conservation potential within the "other industrial users" category is in cooling and landscape watering, which are uses common to most facilities. Commercial landscapes are usually maintained by contractors whose priority is a lush appearance and who may not adjust automatic irrigation controller clocks to match weather conditions. Smaller cooling towers may not be managed as efficiently as larger towers, nor with water conservation as a high priority.

6.2.4 All Industrial Users Conservation Program

The Third Management Plan conservation program for all industrial users is similar to the Second Management Plan program. All industrial users are required to avoid waste and make diligent efforts to recycle water. Single-pass cooling or heating is not allowed unless the water is reused, and low-flow plumbing fixtures must be used as required by the state or local plumbing code. Since January 1, 1994, the Arizona Statewide Plumbing Code has required the use of low-flow fixtures in new construction throughout the state and some local plumbing ordinances have even more stringent standards.

There are two new landscaping requirements in the Third Management Plan. Industrial users that are not regulated as a turf-related facility or as a new large landscape user are required to use low water use landscape plants where feasible and water with efficient irrigation systems. Improving irrigation efficiency can be a source of major water savings whether the plants have high or low water needs. The Department encourages all facilities to irrigate efficiently regardless of the type of vegetation planted. In addition, industrial users are prohibited from serving groundwater to vegetation planted in a public right-of-way after January 1, 2002 unless the plants are on the Low Water Use/Drought Tolerant Plant List for the AMA and are prohibited from serving groundwater to a water feature in the right-of-way if installed after January 1, 2002.

6.2.5 Industrial Conservation Requirements and Monitoring and Reporting Requirements for All Industrial Users

6-201. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-202 through 6-203 of this chapter shall have the following meanings:

1. *"Industrial process purposes" means water that is used by an industrial user directly in the creation or manufacture of a product.*

2. *"Industrial use" means a non-irrigation use of water not supplied by a city, town, or private water company, including animal industry use and expanded animal industry use.*

3. *"Industrial user" means a person who uses water for industrial uses.*

4. *"Low-flow plumbing fixture" means a lavatory faucet, lavatory faucet replacement aerator, kitchen faucet, kitchen faucet replacement aerator, shower head, urinal, water closet, or evaporative cooler designed to meet the use rates specified in A.R.S. §§ 45-312 and 313 or the applicable county or city code, whichever is more restrictive.*

5. *"Single-pass cooling and heating" means the use of water without recirculation to increase or decrease the temperature of equipment, a stored liquid or a confined air space.*

6. *"Wastewater" means water that is discharged after an industrial or municipal use, excluding effluent.*

6-202. Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user shall comply with the following requirements:

1. *Avoid waste; use only the amount of water from any source, including effluent, reasonably required for each industrial use; and make diligent efforts to recycle water.*

2. *Do not use water for non-residential single-pass cooling or heating purposes unless the water is reused for other purposes.*

3. *Use low-flow plumbing fixtures as required by Title 45, Chapter 1, Article 12, Arizona Revised Statutes, or any applicable county or city code, whichever is more restrictive.*

4. *Use plants listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List or any modifications to the list, for landscaping to the maximum extent feasible, and water with a water-efficient irrigation system. An industrial user regulated as a turf-related facility under sections 6-301, et seq., or as a new large landscape user under section 6-901, et seq., is exempt from this requirement.*

5. *Do not serve or use groundwater for the purpose of watering landscaping plants planted on or after January 1, 2002 within any publicly owned right-of-way of a highway, street, road, sidewalk, curb, or shoulder that is used for travel in any ordinary mode, including pedestrian travel, unless the plants are listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List or any modifications to the list. The director may waive this requirement upon request from the industrial user if a waiver is in the public interest. This requirement does not apply to any portion of a residential lot that extends into a publicly owned right-of-way.*

6. *Do not serve or use groundwater for the purpose of maintaining water features, including fountains, waterfalls, ponds, water courses, and other artificial water structures, installed after January 1, 2002 within any publicly owned right-of-way of a highway, street, road, sidewalk, curb, or shoulder that is used for travel in any ordinary mode, including pedestrian travel. The director may waive this requirement upon request from the industrial user if a waiver is in the public interest. This requirement does not apply to any portion of a residential lot that extends into a publicly owned right-of-way.*

6-203. Monitoring and Reporting Requirements

A. Requirements

For calendar year 2002 or the calendar year in which the facility first begins to use water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user shall, except as provided for in subsection B of this section, include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water by source, including effluent, withdrawn, diverted, or received during the reporting year for industrial process purposes, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et. seq.*

2. *The total quantity of water by source, including effluent, withdrawn, diverted, or received during the reporting year for purposes other than industrial process purposes, listed in paragraph 1 of this subsection, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et. seq.*

3. *An estimate of the quantity of wastewater generated during the reporting year.*

4. *An estimate of the quantity of wastewater recycled during the reporting year.*

5. *A description of the primary purposes for which water from any source, including effluent, is used.*

6. *The number of acres of land that were planted with low water use plants during the calendar year as a result of removal of plants not on the Low Water Use/Drought Tolerant Plant List for the Tucson AMA or any modifications to the list, if more than one acre, and the method of irrigation for those acres. An industrial user regulated as a turf-related facility under sections 6-301, et seq., or as a new large landscape user under section 6-901, et seq., is exempt from this requirement.*

B. Exemption

An industrial user who holds a Type 1 or Type 2 non-irrigation grandfathered right or a groundwater withdrawal permit in the amount of 10 or fewer acre-feet per year is exempt from the requirements set forth in subsection A of this section, unless the industrial user holds more than one such right or permit in the aggregate amount of more than 10 acre-feet per year and withdraws more than 10 acre-feet of water during the calendar year pursuant to those rights or permits.

6-204. Remediated Groundwater Accounting for Conservation Requirements

A. Accounting

Groundwater withdrawn pursuant to an approved remedial action project under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or Title 49, Arizona Revised Statutes, and used by a person subject to a conservation requirement established under this chapter, shall be accounted for consistent with the accounting for surface water for purposes of determining the person's compliance with the conservation requirement, subject to the provisions of subsections B through D of this section.

B. Amount of Groundwater Eligible for Accounting

For each approved remedial action project, the annual amount of groundwater that is eligible for the remediated groundwater accounting provided in subsection A of this section is the project's annual authorized volume. The annual authorized volume for a remedial action project approved on or after June 15, 1999 is the maximum annual volume of groundwater that may be withdrawn pursuant to the project, as specified in a consent decree or other document approved by the United States Environmental Protection Agency (EPA) or the Arizona Department of Environmental Quality (ADEQ). The annual authorized volume for a project approved prior to June 15, 1999 is the highest annual use of groundwater withdrawn pursuant to the project prior to January 1, 1999, except that if a consent decree or other document approved by the EPA or ADEQ specifies the maximum annual volume of groundwater that may be withdrawn pursuant to the project, the project's annual authorized volume is the maximum annual volume of groundwater specified in that document. The director may modify the annual authorized volume for a remedial action project as follows:

1. *For an approved remedial action project associated with a treatment plant that was in operation prior to June 15, 1999, a person may request an increase in the annual authorized volume at the same time the notice is submitted pursuant to subsection C of this section. The director shall increase the annual authorized volume up to the maximum treatment capacity of the treatment plant if adequate documentation is submitted to the director demonstrating that an increase is necessary to further the purpose of the remedial action project and the increase is not in violation of the consent decree or other document approved by the EPA or ADEQ.*

2. *A person may request an increase in the annual authorized volume of an approved remedial action project at any time if it is necessary to withdraw groundwater in excess of the annual authorized volume to further the purpose of the project. The director shall increase the annual authorized volume up to the maximum volume needed to further the purpose of the project if adequate documentation justifying the increase is submitted to the director and the increase is not in violation of the consent decree or other document approved by the EPA or ADEQ.*

3. *The director shall modify the annual authorized volume of an approved remedial action project to conform to any change in the consent decree or other document approved by the EPA or ADEQ if the person desiring the modification gives the director written notice of the change within thirty days after the change. The notice shall include a copy of the legally binding agreement changing the consent decree or other document approved by the EPA or ADEQ.*

C. Notification

To qualify for the remediated groundwater accounting provided in subsection A of this section, the person desiring the accounting must notify the director in writing of the anticipated withdrawal of groundwater pursuant to an approved remedial action project under CERCLA or Title 49, Arizona Revised Statutes, prior to the withdrawal. At the time the notice is given, the person desiring the accounting must be using remediated groundwater pursuant to the approved remedial action project or must have agreed to do so through a consent decree or other document approved by the EPA or ADEQ. The notice required by this subsection shall include all of the following:

1. *A copy of a document approved by ADEQ or the EPA, such as the Remedial Action Plan (RAP), Record of Decision (ROD) or consent decree, authorizing the remediated groundwater project. Unless expressly specified in the document, the person shall include in the notice the volume of groundwater that will be pumped annually pursuant to the project, the time period to which the document applies, and the annual authorized volume of groundwater that may be withdrawn pursuant to the project.*

2. *The purpose for which the remediated groundwater will be used.*

3. *The name and telephone number of a contact person.*

4. *Any other information required by the director.*

D. Monitoring and Reporting Requirements

To qualify for the remediated groundwater accounting for conservation requirements as provided in subsection A of this section, groundwater withdrawn pursuant to the approved remedial action project must be metered separately from groundwater withdrawn in association with another groundwater withdrawal authority for the same or other end use. A person desiring the remediated groundwater accounting for conservation requirements shall indicate in its annual report under A.R.S. § 45-632 the volume of water withdrawn and used during the previous calendar year that qualifies for the accounting.

6.3 TURF-RELATED FACILITIES

6.3.1 Introduction

A turf-related facility is a facility with 10 or more acres of water-intensive landscaped area. Golf courses, parks, schools, cemeteries, and common areas within residential developments are examples of facilities that often qualify as turf-related facilities. Because "irrigation" is defined in the Code as water applied for the purpose of growing crops for sale or consumption, turf-related watering for recreational and aesthetic purposes is considered a non-irrigation water use rather than an irrigation use.

Turf-related facilities regulated under the Industrial Conservation Program obtain groundwater pursuant to Type 1 or Type 2 non-irrigation grandfathered rights or permits. In addition, a large number of turf-related facilities are served groundwater by municipal water providers and are also subject to the conservation requirements set forth in this section through provisions of the Municipal Conservation Program (See Chapter 5). These municipally-served facilities are called individual users.

Second Management Plan conservation requirements and other factors have led to changes in turf-related facilities. New facilities are typically designed with less water-intensive acreage, both existing and new facilities employ technology that applies water more efficiently, and facility management has become more cognizant of the need for water conservation.

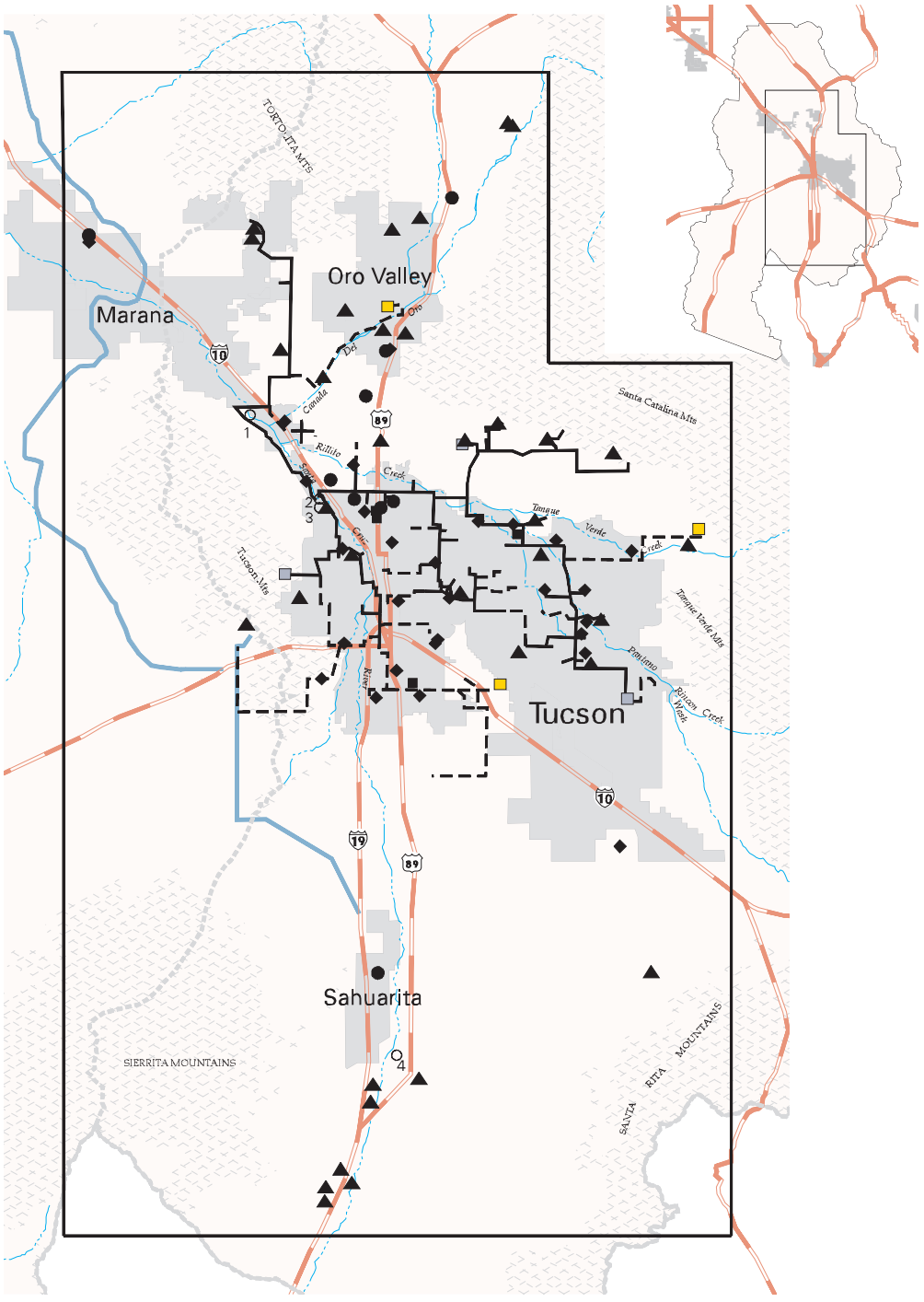
6.3.2 Water Use by Turf-Related Facilities

Turf-related facilities apply water for growing turfgrass and other landscaping plants and for filling and maintaining water levels in bodies of water. Water application efficiency is determined by the type of water application system that is utilized, maintenance of the system, water application scheduling, site topography, soil type, weather conditions, and water quality. There are 72 turf-related facilities in the Tucson AMA, including golf courses, parks, schools, and cemeteries. Common areas within residential subdivisions are subject to regulation as turf-related facilities if they have 10 or more acres of water-intensive landscaping, but none have been identified in the Tucson AMA. The location of Tucson AMA turf-related facilities and sources of effluent are shown in Figure 6-1.

There is a direct relationship between the number of acres of water-intensive landscaping maintained within a facility and the facility's water use. In 1995, turf-related facilities in the Tucson AMA encompassed a total of 4,215 acres of turf and 149 acres of water surface area. From 1987 through 1995, the average annual water application rate on turf acres within turf-related facilities has ranged between 4.3 and 4.7 acre-feet per acre. Golf courses tend to be the largest turf-related facilities, typically having at least 60 acres of turf. Parks make up the majority of the smaller turf-related facilities, usually having less than 40 turf acres.

The water use rate for maintaining bodies of water is higher than for turf and low water use landscaping because evaporation from the water surface (approximately 5.8 feet per year) is higher than the consumptive use and evaporation rates for plants. Unlined or inadequately sealed water holding basins can lose significant volumes of water through seepage. The bodies of water associated with turf-related facilities are most often constructed on golf courses, although a few parks feature recreational bodies of water.

In 1995, turf-related facilities in the Tucson AMA maintained a total of 232 acres of low water use landscaping that was irrigated with a permanent watering system, such as a drip irrigation system. Low water use landscaping water requirements tend to be highest during the first three years when new plants become established. Application rates for low water use landscaping are typically much lower than for turfgrass.



- Golf Course
- School
- Park
- Cemetery
- Water Treatment Site
- Existing Pipeline - Tucson reclaimed water distribution system
- Proposed Pipeline - Tucson reclaimed water distribution system
- Subbasins
- AMA Boundary
- Incorporated Areas
- Hardrock
- Proposed Reservoir
- Existing Reservoir

1 Ina Rd Water Pollution Control Facility
2 Roger Rd Wastewater Treatment Plant
3 Tucson Water Reclaimed Water Plant
4 Green Valley Wastewater Treatment Plant

Figure 6- 1

Location of Turf Related Facilities And Effluent Sources

0 1.8 3 5 7
Miles

North

ORIGINAL SOURCE

Arizona Department of Water Resources
Geographic Information System

"Water use efficiency" refers to the relationship between the physiological needs of the plants being watered and the amount of water actually applied. Turf-related watering is normally expressed in terms of acre-feet per acre per year. Average turf application rates at turf-related facilities may be estimated by subtracting the estimated water use for low water use landscaping acres and lake acres (calculated by multiplying the number of acres of low water use landscaping and water surface area by the application rates of 1.5 acre-feet per acre and 5.8 acre-feet per acre, respectively) from total water use. In 1995, the estimated turf application rates for different types of facilities in the Tucson AMA varied from 3.5 to 4.7 acre-feet per acre per year. This range is indicative of the broad spectrum of water use patterns among the types of turf-related facilities. Parks tend to have the lowest application rate, while golf courses tend to have the highest. Facility acreage attributes and water application rates are detailed in Table 6-1.

TABLE 6-1
1995 ACREAGE AND WATER USE BY TURF-RELATED FACILITIES
INDUSTRIAL USERS AND MUNICIPAL INDIVIDUAL USERS
TUCSON ACTIVE MANAGEMENT AREA

Turf-Related Facilities		Total Acreage			Water Application	
Type	Number	Turf	Total Water Surface Area	Low Water Use Landscaped Area	Total Water Use (acre-feet)	Application Rate for Turf Acres (acre-feet/acre)[1]
Golf Courses	32	3,251	101	208	16,154	4.9
Parks	26	602	48	0	2,380	3.5
Cemeteries	4	178	0	0	674	3.8
Schools	10	184	0	26	805	4.4
TOTAL[2]	**72**	**4,215**	**149**	**232**	**20,013**	**4.5**

[1] Average application rates for turf acres were derived by subtracting the estimated water for water surface area and low water use landscaped area from the reported 1995 water use and dividing by the number of turfed acres reported on 1995 water use reports.
[2] Numbers may not add up exactly due to rounding.

Turf-related facility water use in the Tucson AMA has increased from 17,900 acre-feet in 1987 to 20,013 acre-feet in 1995. While total water use has increased, it continues to be below the cumulative Second Management Plan maximum annual water allotment of 21,922 acre-feet for all turf-related facilities.

Turf-related facility water demand is met through various sources, including:

- Groundwater pumped pursuant to Type 1 and Type 2 non-irrigation grandfathered rights;
- Groundwater pumped pursuant to groundwater withdrawal permits;
- Groundwater served by municipal water providers;
- Effluent served via the City of Tucson's reclaimed water system;
- Effluent from Pima County wastewater treatment plants;
- Effluent from privately operated wastewater treatment plants; and
- Effluent or CAP water stored underground and recovered pursuant to water storage credits.

In 1995, 38 percent of the water used on turf-related facilities was groundwater withdrawn pursuant to industrial rights. The remaining 62 percent was water served by municipal providers. The volume of

groundwater served by municipal providers to turf-related facilities has remained fairly constant, while the volume of effluent being served has increased. Increased utilization of effluent by both existing and new turf-related facilities is due largely to the City of Tucson's commitment to the expansion of its reclaimed water distribution system. Water sources used in 1995 are detailed in Table 6-2.

TABLE 6-2
1995 TURF-RELATED FACILITY WATER USE BY SOURCE
TUCSON ACTIVE MANAGEMENT AREA

Type	Number of Facilities		Water Source (acre-feet)			
	Municipal	Industrial	Municipal		Industrial	
			Groundwater	Effluent	Groundwater	Effluent
Golf Courses	20	12	4,988	4,871	5,599	696
Parks	22	4	1,080	973	327	0
Cemeteries	0	4	0	0	589	86
Schools	2	8	141	0	664	0
TOTAL	**44**	**28**	**6,209**	**5,844**	**7,179**	**782**

Annual water demand by turf-related facilities is anticipated to reach 31,000 acre-feet by 2025. Golf course projections are based on information provided by specific development plans, development companies and public parks and recreation departments. Golf course construction is closely tied to development of golf-centered retirement communities. It is anticipated that 21 additional golf courses will be built in the Tucson AMA by 2025. Projections for parks, cemeteries, and schools assume that turfed acreage will increase commensurate with the regional population. The majority of new large turf-related facilities is expected to be golf courses. The current trend in the Tucson AMA to construct new schools, cemeteries, and parks with less than ten acres of water-intensive landscaped area is expected to continue.

Only about 12,000 acre-feet of the year 2025 turf-related facility water demand is expected to be met with groundwater withdrawn pursuant to industrial rights. The remaining 19,000 acre-feet of demand is anticipated to be served by municipal providers with the majority of it being met by effluent. Zoning code amendments passed by the Pima County Board of Supervisors in November, 1995 require that all new golf courses must use effluent or CAP water for turf-related watering, if available. Groundwater may be used if renewable supplies cannot reasonably be made available, but groundwater use must be offset by recharging CAP water. The City of Tucson has a policy that requires use of effluent by new turf-related facilities where feasible. Since 1983, all new golf courses served by Tucson Water have been connected to the reclaimed water system. This policy is expected to continue because of public opinion and because of the provision in the Municipal Conservation Program of the management plan that exempts direct effluent deliveries from a provider's GPCD calculation. The Town of Oro Valley is committed to serving renewable water to all turf-related facilities within its water service area by the year 2000. The Town of Marana has indicated that it will adopt similar zoning standards for new golf courses.

Compliance with GPCD conservation requirements usually prevents private water companies from serving new golf courses. Consequently, some developers have expressed their intent to participate in underground storage and recovery projects to generate storage credits. Stored water recovered by a turf-related facility from within a municipal provider's service area is not counted in the provider's GPCD usage rate, if the recovery is pursuant to a recovery well permit held by the turf-related facility.

6.3.2.1 Golf Courses

In the Tucson AMA, golf courses include par-three courses and 9, 18, 27, and 36 hole facilities. Non-regulation courses, those shorter than 6,200 yards in total length, have less turfed acres than regulation courses. Golf courses are composed of tees, greens, fairways, and roughs. The most frequently used types of warm season grass are common or hybrid bermuda grass (*Cynodon*) with hybrid bermuda or bent grass (*Agrostis*) used primarily on greens. All golf courses overseed their tees and greens with rye grass (*Lolium*) in winter unless they have bentgrass greens. During the 1990s, some golf courses began experimenting with using lower water use grass species such as buffalo grass (*Buchloe*), curly mesquite grass (*Hilaria*), and purple three-awn (*Aristida*) in rough areas as a water conservation measure.

A high proportion of resort golf courses overseed at least the fairways during the winter months. There is a great deal of variability in overseeding patterns on public and private courses. Some courses prefer to avoid the expense, maintenance problems and stress to the turf associated with overseeding fairways. Some golfers appreciate the better playability associated with dormant bermuda grass. Other facility managers feel strongly that a green appearance during the winter months is required to attract visitors to golf courses in Arizona. There is strong interest in turf appearance for all golf courses, particularly resort courses and courses associated with housing developments that emphasize aesthetics rather than maximum playability and water conservation during the winter.

Golf course water application systems are often more sophisticated than those at other turf-related facilities. Most have a system with a control panel and field satellites that can override the central controller. Computer-controlled watering systems and pump stations with flexibility in operating sprinkler heads are commonplace; newer systems provide much greater savings in energy and water costs than water delivery systems of ten years ago. Most of the newer systems can incorporate weather stations that assist in scheduling water application to more accurately replace the amount of water lost through evaporation and transpiration. Most courses apply water to greens and tees with spray heads; larger turf areas are watered with large radius heads. Water is typically pumped into the watering system from a reservoir or a storage tank.

Turf managers who are knowledgeable of water conservation technologies and practices are critical to program effectiveness. Taking advantage of a computerized system's ability for field-adjusting water distribution uniformity or the percentage of points within the area being watered that receive equivalent amounts of water, routine leveling of heads, and frequent verification of proper operation of all controllers and heads are examples of prudent management.

There were 32 golf courses in the Tucson AMA in 1995. These courses used 16,154 acre-feet of water in 1995, which was 81 percent of the water used by all turf-related facilities that year, and 27 percent of the water used by all users regulated under the Industrial Conservation Program that year including individual users. In 1995, golf courses used 5,599 acre-feet of groundwater withdrawn pursuant to industrial rights. This represents 9 percent of the total amount of groundwater withdrawn pursuant to such rights in 1995.

Golf course demand has remained fairly constant since 1987 even with the addition of five new courses. As expected, application rates increase proportionately to evapotranspiration rates in dry, hot years, although a less commensurate decrease in application rates has not been observed in wetter, cooler years. The average water application rate for turfed acreage was 4.7 acre-feet per acre in 1995.

6.3.2.2 Parks

Public parks maintain turf for playing surfaces, for aesthetic reasons, and for erosion control. Maintenance of public parks is usually coordinated through a central office without the presence of on-site staff on a daily basis. Parks commonly have inefficient water application systems, although newer parks are

installing more efficient systems, including drip irrigation and controllers that have water budgeting capacity. Large radius impact heads are frequently used. Vandalism is a significant problem, requiring specialized tamper-proof heads. Bermuda grass is the only species planted, with rye grass overseeding limited to only a few baseball fields. More relaxed turf appearance standards and lack of overseeding have resulted in much lower application rates than those achieved by golf courses, schools, and cemeteries.

Total water use for 26 parks was 2,380 acre-feet in 1995. The average water application rate for turf acreage was 3.5 acre-feet per acre. Only 17 percent of the park demand is served with groundwater withdrawn pursuant to industrial rights, the rest is served by municipal providers. About half of the municipally-served parks receive effluent as their sole water source for turf-related watering. Nearly a third of the parks in the AMA are under 20 acres in size. The largest, Reid Park, has just under 77 acres of water-intensive landscaped acreage with effluent being the only water source utilized for landscape watering and maintaining water levels in bodies of water within the park.

6.3.2.3 Schools

The main function of turf in school yards is to provide an appropriate surface for active play. School managers have determined that using low water application rates can save money without adversely impacting turf use. Bermuda grass is the only species used and is seldom overseeded. Although athletic fields tend to be maintained at a higher turf quality than the balance of school yards, more relaxed appearance standards and limited overseeding allow much lower application rates than those achieved by golf courses.

Water application systems at schools are usually relatively inflexible. In older schools, outdated equipment, including quick coupler systems, are common. Newer facilities have in-place sprinkler heads with manual or electromechanical control. Some schools have converted non-play areas to drip irrigation. Due to budget constraints, it is difficult for schools to install computerized controllers, and systems are frequently manually operated.

Turf acreage within schools is comparatively small. The largest facility is Marana Junior High School with 30 turf acres. Seven facilities are less than 20 acres in size. Water application rates for turf at schools are low, compared to other turf-related facilities, with an average of 3.7 acre-feet per acre. None of the schools regulated as turf-related facilities in the Tucson AMA receives effluent for turf-related watering. Tucson Unified School District is actively converting its turf-related watering to effluent at schools that have access to the City of Tucson's reclaimed water system, although none of these schools was regulated as a turf-related facility under the Second Management Plan.

6.3.2.4 Cemeteries

Cemeteries have several unique characteristics that affect water conservation potential. Cemeteries are developed in stages and are committed to maintaining grave sites in perpetuity in a manner acceptable to the public. Interment activities also cause problems in scheduling of water application. Cemeteries promote an image of a quiet, cool resting place so turf appearance is extremely important.

Water requirements of cemeteries are similar to those of golf courses, although less overseeding is practiced. Because cemeteries are developed in sections, additional water application systems are installed as new areas are opened. The water application system in older areas is often quite different from the system in more recently developed sections. The result is often a complex control system that is difficult to manage. Most cemeteries use electromechanical controllers with a large number of sprinkler heads on each controller. Large radius heads or raised spray heads are frequently used to allow watering around headstones. Several facilities have upgraded their systems and installed drip irrigation for trees and shrubs.

The trend through the 1990's in the Tucson AMA has been to design new cemeteries with a minimum of water-intensive landscaping. The public has accepted this new style of cemetery. An abundance of low water use trees creates a pleasantly shaded environment, low water use shrubs and groundcovers provide color during blooming seasons. None of the new cemeteries in the Tucson AMA is regulated as a turf-related facility.

6.3.3 First and Second Management Plan Program Development

The First Management Plan established a maximum annual water allotment for each turf-related facility and stressed water use efficiency. This was the first time golf course water use was regulated, and water management practices such as evapotranspiration-based water application scheduling was uncommon. The First Management Plan provided for adjustment of turf application rates if effluent was used.

The allotment approach permitted turf managers to consider characteristics of the facility, evaluate conservation alternatives, and decide how to most effectively apply the allotment to meet the facility's needs. A golf course requiring a lush, green appearance during the winter season could choose to reduce the amount of water applied to bermuda grass through the summer season, making a larger portion of the allotment available for extensive cool-season overseeding. Conversely, a golf course could emphasize the playability and lower maintenance of dormant bermuda grass and apply more of the allotment and maximize bermuda grass appearance during the summer season. A golf course that demanded a year-round lush appearance received sufficient allotment to do so, if state-of-the-art water application technologies and water management practices were employed.

The trend throughout the first management period was to convert turf-related facilities from groundwater to effluent use. This conversion was due in large part to City of Tucson policies that require effluent use and by an aggressive reclaimed water system construction program. These efforts continue to the present. The exclusion of direct effluent deliveries from the GPCD calculation in the Municipal Conservation Program also serves as an incentive for water providers to serve effluent to turf-related facilities when available.

Development of the Second Management Plan conservation requirements involved extensive data collection regarding water use patterns in Arizona and the conservation options available to turf-related facility managers. The Department relied heavily on input from the Turf Advisory Committees in the Tucson and Phoenix AMAs, which consisted of golf course, park, cemetery, and school turf managers, turf irrigation specialists, extension agents, and golf course designers.

The Department used consulting services to analyze the water conservation practices in use in the turf industry and the potential for future water conservation. The study evaluated technologies, including management practices and design alternatives associated with water conservation. A primary finding of the study was that management of the water application system, rather than the use of specific water application systems, is the most important factor in efficient landscape watering. The consultant and advisory committees concluded that a combination of good management and use of the latest water application systems was very effective in reducing water use.

For the Second Management Plan, the Department chose not to require specific conservation techniques wherever possible due to the widely varied nature of turf-related facilities. Instead, turf-related facilities continued to receive a maximum annual water allotment based on the use of conservation techniques. The allotment approaches of the First and Second Management Plans permitted turf managers to consider characteristics of the facility, evaluate conservation alternatives, and decide how to most effectively apply the allotment to meet each facility's needs.

The Second Management Plan included an overall decrease in application rates for all turf-related facilities, caps on maximum annual water allotments for new golf courses, and a limitation on the water-

intensive landscaped area within new cemeteries, plus a more specific effluent incentive. In setting the annual water allotments, factors considered included actual water use figures collected from over 400 turf-related facilities in all AMAs. Data on the consumptive use of the grass species most frequently used, water application efficiency achievable with available technologies, evaporative losses from bodies of water based on pond evaporation data, management practices and technologies currently in place, conservation potential associated with additional technologies, practices, and design alternatives, and germination requirements for establishing new turf were compiled and analyzed.

Based on these factors, the Department established final annual application rates in the Tucson AMA of 4.6 acre-feet per acre for turf acres, 5.8 acre-feet per acre for bodies of water and 1.5 acre-feet per acre for low water use landscaping. For golf courses that came into existence after 1984 the maximum annual water allotment could not exceed 23.8 acre-feet per hole. Adjustments to the application rates were provided for establishing new turf, using high salinity water, filling or refilling bodies of water, and revegetating acreage disturbed during construction.

The Department continued to encourage the use of effluent in the Second Management Plan. As an incentive, effluent use, if 50 percent or more of total water use, was discounted when determining a facility's compliance with its maximum annual water allotment.

A review of short-term weather data in the 1980s indicated that a three-year averaging method would adequately compensate for weather fluctuations when determining a facility's compliance with its allotment. A provision for finding a facility in compliance on either an annual or a three-year average basis was included in the Second Management Plan.

The Second Management Plan has proven most successful in changing the design of new facilities by reducing turfed acres without sacrificing functionality. Water use by turf-related facilities is highly correlated to the number of turfed acres within the facilities. Recent school and park designs usually eliminate turf except where essential for recreational purposes, reducing water use for turf. Most parks, schools, and cemeteries built during the second management period in the Tucson AMA have less than 10 acres of water-intensive landscaping and are not regulated as turf-related facilities. Golf course designers have been able to design lower acreage courses without affecting appearance and playability. Generally, improvements in water management and irrigation technology have allowed turf-related facilities to increase the percent of acreage that is overseeded, while maintaining efficient water application rates.

Table 6-3 compares changes in acres per hole for existing and new regulation size golf courses. Since 1985, under both the First and Second Management Plans, new courses have substantially less turf and body of water acres per hole.

Few turf-related facilities in the Tucson AMA have had difficulty complying with their maximum annual water allotments during the second management period. Facilities that have been out of compliance with the requirements have chosen to implement long-lasting conservation technologies and practices, such as relining leaking bodies of water, permanent removal of turf, or the renovation of aging, inefficient watering systems.

6.3.4 Issues and Third Management Plan Development

The Code provides that the conservation program for industrial users shall require the use of or establish conservation requirements based on the use of the latest commercially available and economically feasible water conservation technologies. For turf-related facilities, such technologies include: (1) the use of weather-based water application scheduling and water budgeting; (2) accurate, well-designed water application systems and computerized control mechanisms; (3) golf course design that concentrates water-intensive landscaping in areas that come into play; and (4) PVC liners for bodies of water. Using

TABLE 6-3
AVERAGE LANDSCAPED ACREAGE PER HOLE
EXISTING AND NEW GOLF COURSES
TUCSON ACTIVE MANAGEMENT AREA

Type of Acreage	Existing Golf Courses[1]	New Golf Courses[2]
Turf	5.4	4.7
Bodies of Water	0.17	0.15
Low Water Use Landscaping	0.14	0.81

[1]Existing courses are defined in the Second Management Plan as courses built or substantially commenced by December 26, 1984.
[2]New courses are defined in the Second Management Plan as courses built or substantially commenced after December 26, 1984

new low water use and drought tolerant turfgrasses, improving conservation knowledge and awareness by facility management, and converting industrial users to renewable supplies are ways turf-related facilities could further contribute to safe-yield.

Technical advisory committees (TACs) in the Phoenix and Tucson AMAs, consisting of golf course, park, school, and cemetery turf managers, golf course directors, golf course architects, industry association representatives, and land developers, have contributed to the development of the Third Management Plan conservation program for turf-related facilities. The committees aided the Department in identifying second management period water use efficiency, water supply and conservation program effectiveness issues, provided and reviewed data and information relevant to the issues, and participated in developing program alternatives for the third management period. The committees worked with the Department to review the merits of all alternatives and to strive for consensus on the program for the third management period. In some cases, subcommittees were formed to address a specific issue and to make a program recommendation to the committee as a whole. These committees and the Department identified the following issues of relevance:

- the allotment methodology
- application rates for turf
- weather adjustment
- renewable supply incentives

6.3.4.1 Allotment Methodology and Application Rates

The Second Management Plan final annual application rates of 4.6 acre-feet per acre for turf acreage, 5.8 acre-feet per acre for bodies of water and 1.5 acre-feet per acre for low-water use landscaping applied to all turf-related facilities. However, for most golf courses constructed after 1984, the maximum annual water allotment was limited to 23.8 acre-feet per hole.

During Third Management Plan development, some representatives of the golf industry argued that the Second Management Plan application rates for turf and the cap on the allotment for golf courses constructed after 1984 denied golf courses their legal right to sufficient groundwater to meet their actual needs consistent with their selected business practices. They felt that the Department's program unreasonably prevented the complete overseeding of golf courses, interfered with reasonable management of longer courses needed to attract high-visibility tournaments, and resulted in target-style courses that imposed unreasonable skill demands on inexperienced and older golfers. They asserted that the allocations were not supported by sufficient data. Other TAC members felt that Second Management Plan application rates and allotment limitations were supported by scientific research and, that while potentially challenging

to superintendents and designers, the allotments were adequate assuming the use of high-quality water application systems and conscientious water management practices.

Factors influencing turf watering needs include temperature, solar radiation, humidity, wind, and soil moisture. Based on research conducted at the University of Arizona Desert Turf Research Center (Brown, Gilbert, and Kopec, 1996) and 1988 to 1996 weather data from the Arizona Meteorological Network (AZMET) Tucson Station, high-quality turf with winter overseeding would need 4.5 to 5.2 acre-feet per acre per year of applied water depending upon the weather conditions of that year, not including rainfall. This research supports the adequacy of the Second Management Plan's 4.6 acre-feet per acre per year application rate for maintaining overseeded turf.

The parameters assumed in the research are conditions that may lead to a long-term root zone salt accumulation, depending upon the quality of the water applied to turf. Additional investigation is needed to determine if typical rainfall distribution will adequately flush accumulated salts beyond the turfgrasses' root zone or, if rainfall is not sufficient, if continuous water application at a slightly higher rate or periodic flushing at a much higher application rate would best balance salt management and water application efficiency.

Because regional variation in rainfall, wind speed during watering times, soil type, root zone depth, and course topography can all have potential negative impacts on turf water demand, application rates deemed sufficient for the majority of facilities may not be appropriate for all facilities. Individual facilities with special circumstances that could render these application rates unreasonable may seek relief through administrative review. A.R.S. § 45-575.

While the maximum annual water allotment provisions do not directly limit water-intensive acreage of new golf courses, acreage limitations are incorporated into the derivation of the 23 acre-foot per hole allotment cap for turf acres and low water use landscaped area and the 0.8 acre-foot per hole allotment cap for water surface acres. Among the conservation technologies currently available to golf course developers, minimizing water-intensive acreage is one of the most effective means of reducing water demand. Both the turf-related facility study conducted by the Department during development of the Second Management Plan and numerous articles in golf industry trade journals during the past 15 years point to smaller turfed areas as an effective means for golf courses to save water and reduce operating costs. Eighteen-hole golf courses with about 90 acres of turf were found to be more manageable while still being around 7,200 yards in length. Bodies of water with 2 to 3 acres of surface area allow for sufficient storage capacity to hold three to five days worth of peak facility water demand. The allotment cap is based on these acreage guidelines for an 18-hole course multiplied by the application rates for turfed and water surface area, expressed on a per hole basis. All of the golf courses constructed in the Tucson AMA since 1990 were designed with less than 90 acres of turf for 18 holes.

Historic water use and research in California indicates that the higher unirrigated perimeter to turfed acre ratios typical of target-style courses may result in higher water demand per acre than that of more traditionally-designed courses. Increased evapotranspiration may occur within 200 feet of perimeters adjacent to unwatered or low water use areas. On narrow fairways these zones may coincide, and water demand for the entire turfed area may increase on the order of 5 percent. In order to quantify this effect for possible inclusion in management plan requirements, additional research needs to be conducted in the desert regions of Arizona.

6.3.4.2 Weather Adjustment

Long-term weather data indicate that the mid-1980s and early 1990s represented a comparatively "wet" period. Historically, rainfall in the Tucson AMA tends to be cyclic with "dry" or "wet" periods that may last as long as four or five years. Wet years early in the second management period were followed by a

protracted period of hot summer weather combined with sparse or late summer rains. Consequently, in 1996 and 1997, an unusually large number of turf-related facilities began to experience difficulty in complying with their annual water allotments.

Alternatives were considered to the three-year averaging approach for determining compliance used in the Second Management Plan in order to compensate for weather fluctuations more effectively. These alternatives included a flexibility account and a five-year averaging provision. For the Third Management Plan, the Department chose not to extend the three-year averaging provision to five years. The length of a five-year averaging provision would result in a considerable lag between the time the annual allotment was exceeded and when corrective action could be taken. Instead, the Department opted for a flexibility account that contains both credit and debit limits. Credit and debit limits for the flexibility account have been set at 20 percent of the maximum annual water allotment based on an analysis of the 1988 through 1997 weather variations. The account will encourage and reward careful management through the accrual of credits.

6.3.4.3 Renewable Supply Incentives

While many new facilities are served alternative water sources by municipal providers, existing industrial users continue to pump groundwater. Conservation requirements strive for efficient use but cannot eliminate the contribution to overdraft by industrial users. The availability of Type 2 non-irrigation grandfathered rights through purchase or lease, the conversion of irrigation grandfathered rights to Type 1 non-irrigation grandfathered rights, the issuance of groundwater withdrawal permits, and the delivery of groundwater by municipal water providers are all prospects that could increase groundwater use by turf-related facilities in the future and further increase overdraft in the Tucson AMA.

The cost of using renewable water supplies is a major consideration for those turf-related facilities operating their own wells, because it is considerably cheaper to pump and use groundwater than to purchase effluent from the City of Tucson. In 1997, the cost of effluent served through the reclaimed water system was $462 per acre-foot. While this rate is less than potable water service from the City and most other municipal water providers, reclaimed water rates are partially subsidized by potable water sales and other revenue-generating activities. Extensions of the reclaimed water system to other water providers' service areas by the City of Tucson must be justified to the City's potable water ratepayers.

In the Second Management Plan, the effluent use incentive was structured so that if at least 50 percent of a facility's applied water was effluent, the volume of effluent used was discounted. The amount of the discount was 5 percent if up to 89 percent of the total water use was effluent and 10 percent if 90 percent or more of the total water use was effluent. Also, the cap placed on the allocation given for bodies of water within new golf courses did not apply to bodies of water filled entirely with effluent.

The cost and availability of effluent delivery and the policies of municipal water providers and local jurisdictions primarily determine effluent use for turf-related watering in the Tucson AMA. In addition to reserving high-quality groundwater for potable uses, serving effluent for turf-related watering provides further community benefits. Excluding direct deliveries of effluent from a municipal provider's gallons per capita per day conservation requirement makes effluent use attractive to water providers. Effluent reuse also eases peak demand impact on potable water systems. Avoidance of lengthy permitting processes and treatment costs incurred when effluent is discharged into public waterways makes reuse attractive to wastewater treatment authorities. Effluent reuse can also help to reduce groundwater pumping in areas experiencing substantial water level declines or land subsidence potential.

The Department and the Third Management Plan Turf TACs discussed several incentives that would further encourage effluent and CAP water utilization by both municipally provided facilities and industrial users in the Third Management Plan. Because effluent is an underutilized supply, the Department chose to

discount all direct effluent use by 30 percent. The discount will provide a significant incentive to encourage effluent use where supplies are expensive and will encourage the construction of wastewater treatment plants to produce effluent in new developments, where supplies may be limited until residential development nears completion. The incentive acknowledges the need for efficient use of all water supplies, while providing a higher potential application rate to facilities using higher percentages of effluent. Agronomic research has shown that high quality turfgrass can be maintained through application of approximately 75 percent of the measured evapotranspiration rate. As effluent use approaches 100 percent of a facility's total water use, the 30 percent effluent discount will allow a typical golf course to apply the full amount of water lost by turfgrass through evaporation and transpiration.

The Department and the TACs also explored options to allow a turf-related facility to mitigate water use in excess of the annual water conservation allotment. If more groundwater is used at a turf-related facility than allowed by its annual water allotment, a net benefit could be provided to the aquifer either through recharging without earning credits (known as storing "non-recoverable" water) or extinguishing existing recharge credits at a higher rate than the excess groundwater used at the facility. Issues considered included the rates of recharge required, conditions that would apply to ensure no wasteful practices are condoned, the effect on water conservation efforts, and the effect of excessive pumping upon localized groundwater conditions.

The Department determined that this option will not be included as a part of the conservation requirements for turf-related facilities during the third management period. In the meantime, the option of extinguishing recharge credits or storing non-recoverable water in particular areas as a compliance mechanism will be considered during the third management period, even in advance of a violation. Owners and operators of turf-related facilities who anticipate an allotment violation are encouraged to develop a proactive response program in cooperation with the Department (See Chapter 10).

6.3.5 Turf-Related Facilities Conservation Program

6.3.5.1 Maximum Annual Water Allotment

6.3.5.1.1 Base Allotment

The core of the conservation program for turf-related facilities is the maximum annual water allotment. The allotment is calculated differently for different types of facilities, but generally there is a direct relationship between the number of acres to which water is applied and the volume of the allotment. For all turf-related facilities, the annual application rate for turf acres is 4.6 acre-feet per acre, the application rate for water surface acres is 5.8 acre-feet per acre, and the application rate for low water use landscaped area is 1.5 acre-feet per acre.

For turf-related facilities other than golf courses, the allotment is calculated by determining the actual acreage within the facility in each of the three landscaping categories and then multiplying the number of acres by the appropriate application rate. The approach used for these facilities allows expansion of landscaped area. Beginning with the First Management Plan, the Department recognized that the latest conservation technology for golf courses includes course design that concentrates water-intensive landscaping into areas that come into play and water management practices that adjust water application schedules for weather conditions and seasons of highest play. The allotment for golf course acreage that came into existence after December 31, 1984 is therefore capped to encourage efficient design, construction, water application, and overseeding practices. These caps are described below.

Golf course acreage that came into existence from January 1, 1985 through December 31, 1991 - For golf courses, the allotment for any turf acres that came into existence from January 1, 1985 through December 31, 1991 is limited to an amount calculated by multiplying the number of holes within those acres by 23

acre-feet of water per hole, plus any allotment additions described later in this section. This cap is sufficient to water 5 acres of turf at 4.6 acre-feet per acre. If the turf acres planted during that period are in fact limited to 5 acres per hole, there is no cap on the allotment for any bodies of water that came into existence within the facility from January 1, 1985 through December 31, 1991. However, if the turf acres planted from January 1, 1985 through December 31, 1991 exceed 5 acres per hole, the allotment for any bodies of water that came into existence during that period and that are not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact is limited to an amount calculated by multiplying the number of holes within those turf acres by 0.8 acre-feet of water, plus any allotment additions described later in this section.

Golf course acreage that came into existence after December 31, 1991 - For golf courses, the total allotment for turf acres and low water use landscaped area that came into existence after December 31, 1991 is limited to an amount calculated by multiplying the number of holes within those acres by 23 acre-feet of water, plus any allotment additions described later in this section. This cap is sufficient to water 5 acres of turf at 4.6 acre-feet per acre. If less than five acres of turf are planted per hole, the cap allows sufficient water for approximately 3 acres of low water use landscaping in place of each acre of turf not planted. The allotment for all bodies of water that came into existence after December 31, 1991 and that are not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact is limited to an amount calculated by multiplying the number of holes within the turf acres that came into existence after December 31, 1991 by 0.8 acre-feet of water. This cap limits the allotment for such bodies of water to 0.14 acre of water surface per hole.

Golf courses may expand or develop any number of water-intensive landscaped acres and low water use landscaped area. However, water use must not exceed the maximum annual water allotment, which assumes acreage restrictions. Although the allotment is calculated on a per acre basis, the facility manager has discretion on how to apply the allotment within the facility.

6.3.5.1.2 Allotment Additions

Under certain circumstances, a turf-related facility is entitled to an addition to its base allotment. In some cases, the allotment addition is effective only for one year; in other cases, the allotment addition is effective for a longer period. The following are the allotment additions allowed in the Third Management Plan.

Reduction of Turfed Acreage

Conservation requirements for the third management period continue to provide an incentive to reduce landscaped area. When calculating the maximum annual water allotment for a turf-related facility, the amount of water allotted to pre-1985 turf, water surface acres, and low water use landscaping is based on the highest number of those acres in existence at the facility during the period from 1980 through 1984. Thus, removal of acreage planted during that period will not decrease the facility's allotment. All turf-related facilities are encouraged to minimize the water-intensive landscaping to areas consistent with the intended use and enjoyment of the facility.

Allotment Addition for Establishment of Newly Turfed Area

An allotment addition is given to turf-related facilities for the establishment of newly planted turf. The allotment addition is equal to 1.0 acre-feet per acre of newly turfed area, and is limited to the year in which the turf is planted. For golf courses, the allotment addition is limited to an amount calculated by multiplying the number of holes present within the newly turfed area by 5 acre-feet of water.

Allotment Addition for Revegetation

A revegetation allotment addition is available to facilities that want to establish low water use or other site-adapted landscaping plants that will need only temporary supplemental water application after construction of a new or renovated facility. This allotment addition of up to 1.5 acre-feet per acre for up to a maximum of three calendar years, is quantified and granted on an individual basis through an application process. The quantity and duration of the allotment adjustment is determined through the Department's evaluation of each application. This adjustment is separate from the low water use landscaping component included in the maximum annual water allotment calculation, and is not included in the allotment cap for new landscaped areas within golf courses.

Allotment Addition for Filling Bodies of Water

New turf-related facilities receive a one-time allotment addition to fill bodies of water within the facility. The allotment addition is equal to the volume used for initial filling of the body of water and is given only for the year in which the body of water is filled. Any facility may also apply for an allotment addition to refill a body of water that has been emptied for maintenance work to eliminate or reduce seepage losses. The allotment addition may be given only for the year in which the body of water is refilled.

Allotment Addition for Leaching

When high levels of total dissolved solids are present in the water supply, a turf-related facility may need an additional amount of water for leaching, or deep percolation, to prevent salts from accumulating in the root zone. If salts are allowed to accumulate in the soil, salinity may eventually reach levels toxic to turfgrass. Since most water supplies in the Tucson AMA are of a quality that does not require an additional leaching allowance, a leaching allowance was not included in the maximum annual water allotment calculation. However, if a facility's water supply has a concentration of 1,000 milligrams per liter of total dissolved solids (approximately 1.5 millimhos per centimeter of electrical conductivity) or greater, the turf-related facility may apply to the Department for an allotment addition for leaching.

6.3.5.2 Additional Conservation Requirements

All turf-related facilities are required to prepare and maintain a water conservation plan. The plan must outline the water management practices and technologies the facility will utilize to maximize water use efficiency. All turf-related facilities that are not golf courses are required to design, construct, and maintain grounds in a manner that will minimize water-intensive landscaped areas consistent with reasonable use and enjoyment of the facility. Golf courses have a capped maximum annual allotment that assumes water-efficient design and management.

A turf-related facility that is a cemetery must limit the water intensive landscaped area within any portion of the cemetery that came into existence after December 31, 1991, so that no more than 75 percent of the total cemetery area within that portion of the cemetery is landscaped with plants not listed on the Low Water Use/Drought Tolerant Plant List for the Tucson AMA (See Appendix 5B). This restriction does not apply to an expansion of a cemetery onto contiguous land that was under the same ownership as the cemetery as of December 31, 1984.

6.3.5.3 Effluent Use Adjustment

In the Tucson AMA, effluent is the only water supply that is expected to increase in availability throughout the third management period. Effluent's high nutrient content makes it an excellent supply for turf-related watering, as long as the nutrient load is carefully matched to plant needs and over-application of potential

groundwater pollutants is avoided. Despite the availability and suitability of effluent for turf watering, effluent is currently underutilized as a source of water for turf-related facilities.

To encourage the maximum use of effluent on turf-related facilities during the third management period, the Department has modified the effluent incentive offered in the Second Management Plan. While the maximum annual water allotment will not change, each acre-foot of effluent will be counted as 0.7 acre-foot when compliance with the maximum annual water allotment is determined. This adjustment does not apply to effluent stored in a storage facility pursuant to a water storage permit and recovered outside the area of impact of the stored water. In addition to the effluent adjustment, facilities using effluent may apply to the Department for an allotment addition to allow for leaching of salts below the root zone.

6.3.5.4 Flexibility Account

In order to compensate for fluctuating weather conditions, each turf-related facility will have a flexibility account with credit and debit limits. In wetter years or through careful management, facilities will be able to accrue a credit balance up to 20 percent of a facility's annual allotment. When weather conditions or water management decisions cause a facility's water use to exceed its allotment in any year, accrued credits are expended. If all credits are exhausted, a facility may accrue a debit balance up to 20 percent of the allotment. A violation will occur only when all credits have been exhausted and the debit maximum is exceeded. Prudent facility managers will take advantage of wet years and the latest conservation technologies to accumulate as many credits as allowed in order to compensate fluctuations in water demand during hot or dry years.

6.3.5.5 Monitoring and Reporting Requirements

The Third Management Plan includes monitoring and reporting requirements for all turf-related facilities. All turf-related facility water use will be assumed to be for landscape watering purposes unless other water uses are metered separately. For example, if water for domestic uses at a park is not metered, it will count against the facility's allotment. This provision encourages facilities to install enough meters to ensure that turf-related watering is accurately measured and reported.

6.3.6 Non-Regulatory Efforts

In 1991, the Department initiated a grants program for conservation assistance and augmentation of water supplies in the AMAs. Individual AMA programs focus on the areas of highest water conservation potential in each water use sector (municipal, industrial, and agricultural) based on total water usage, current water usage practices, and potential for implementation of new conservation technologies. Funding for the grants program comes from an annual withdrawal fee levied and collected from all regulated groundwater users in the AMAs. See Chapter 9 for a description of the Conservation Assistance Program for the third management period.

During the second management period, over $70,000 was awarded under the Conservation Assistance Grants Program to assist turf-related facilities through evaluation and implementation of conservation strategies. Funded projects include water application scheduling workshops for facility managers, a public school water application system audit and repair program, development of an electronic overwatering controller, and a water application field study that compared turf water demand under high- and low-traffic conditions. The Department is committed to continuing its efforts to assist turf-related facilities in meeting their conservation requirements through direct staff assistance and through the grants program.

Opportunities for future research abound in turf-related water conservation. Anecdotal evidence for golf courses in central and southern Arizona suggests that target-style courses may use more water due to the "edge effect." Further study is needed to quantify the potential water demand impacts of factors that may

be inherent in lower-acreage facility designs. New computer-controlled watering systems, which isolate watering needs of specific areas of turf, could prove to be a useful source of data for verifying this phenomenon. Many computer controlled irrigation systems have been introduced into the market during the last decade. How well turf-related facility managers understand and employ the latest commercially available water application technologies is not well documented.

The watering needs of low water use landscaping need to be more precisely quantified to determine whether the application rate of 1.5 acre-feet per acre is appropriate. Some evidence suggests the rate may be excessive, especially after the first few years when the plants have become established.

Because proper turf management is key to water conservation, the Department will continue to explore opportunities to provide training and assistance to turf managers through the Department's Conservation Assistance Program or other avenues.

Long-term use of water high in total dissolved solids, such as effluent and CAP water, may lead to the need for applying additional water to leach or flush salts below the root zone. Quantifying the long-term implications of using water high in total dissolved solids would enhance understanding the impacts on water application rates and aquifer water quality protection. Conservation assistance funds may be used during the third management period to address these research needs.

6.3.7 Future Directions

In order to achieve the safe-yield goal in the Tucson AMA, a reduction in groundwater use must occur. The current Code provisions limit the Department's ability to achieve this goal since they allow continuing withdrawal of groundwater by existing users, as well as some additional withdrawals by industrial users. Management plan conservation requirements can reduce groundwater pumping by industrial users only to the extent that the requirements are consistent with reasonable economic return. Increased utilization of renewable water supplies combined with efforts to maximize water application efficiency are key factors in meeting the active management area's water management goal. Renewable water supply use requirements similar to current City of Tucson and Pima County ordinances and policies or broader groundwater use prohibitions targeting specific water uses as in the "Lakes" Bill (A.R.S. § 45-131, *et seq.*) are possible legislative approaches. A change to the statutes that would allow the CAGRD to replenish mined groundwater not associated with the demonstration of an assured water supply, combined with a replenishment obligation for all or a portion of mined groundwater used by turf-related facilities, would facilitate greater utilization of renewable supplies and reduce groundwater overdraft.

The relationship of turf-related watering to groundwater overdraft has been evaluated and quantified. Approximately two-thirds of all turf-related water demand in 1995 was met with groundwater. At facilities served by industrial rights, nearly 90 percent of water demand was met with groundwater. Although some component of applied water may actually be incidentally recharged, deep percolation of water that may contain fertilizers, horticultural chemicals, or other potential pollutants could lead to serious water quality issues and should not be encouraged.

Stronger conservation-oriented technology and water management practice requirements should be considered from both a regulatory and non-regulatory perspective. From a regulatory perspective, application rates that determine the maximum annual groundwater allotments need to be further scrutinized under actual field conditions. Research will also need to be conducted to quantify the effects of increased evapotranspiration by turf adjacent to low water use areas. As a result of such research, fourth management period conservation requirements may include an allotment-based requirement that is different from the method used for the second and third management periods, incorporating application rates for turf and low water use landscaping that more closely resemble efficient water use needs for different types of landscaping in actual field conditions. Required use of conservation technologies and

practices should be further evaluated as a regulatory alternative to enforceable allotments. From a non-regulatory approach, legislation that increases funding for conservation, education, and augmentation could assist turf managers with implementing effective water management practices, evaluation of effective water conservation technology, and for construction of renewable water supply conveyance infrastructure.

Development of incentive programs in the context of achieving specific management goals should continue during subsequent management periods. If necessary, efforts to broaden participation in water storage and recovery options could continue as well as renewable supply utilization incentives. Providing additional assistance for education and increased water management efficiency must be a priority to reduce the demand side of the safe-yield equation. Ongoing regional cooperative efforts such as the CAP utilization study for the Green Valley area and the regional effluent planning task force that began in 1997 will be necessary to facilitate widespread use of these supplies by turf-related facilities.

6.3.8 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Turf-Related Facilities

6-301. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, and section 6-201 of this chapter, the following words and phrases used in sections 6-301 through 6-305 of this chapter, unless the context otherwise requires, shall have the following meanings:

1. *"Body of water" means a constructed body of water or interconnected bodies of water, including a lake, pond, lagoon, or swimming pool, that has a surface area greater than 12,320 square feet when full and that is filled or refilled primarily for landscape, scenic, recreational purposes, or regulatory storage.*

2. *"Common area" means an area or areas that is owned and operated as a single integrated facility and that is used for recreational or open space purposes. A common area is maintained for the benefit of the residents of a housing development.*

3. *"Contiguous" means in contact at any point, or part of the same master planned community. Two parcels of land are contiguous even if they are separated by one or more of the following: a road, easement or right-of-way.*

4. *"Direct use effluent" means effluent transported directly from a facility regulated pursuant to Title 49, Chapter 2, Arizona Revised Statutes, to an end user. Direct use effluent does not include effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes.*

5. *"Effluent recovered within the area of impact" means effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes, and recovered within the stored effluent's area of impact. For purposes of this definition, "area of impact" has the same meaning as prescribed by A.R.S. § 45-802.01.*

6. *"First management period new acres" means a water-intensive landscaped area or a low water use landscaped area that came into existence or was substantially commenced after December 31, 1984 and before January 1, 1992, but that was not substantially commenced prior to January 1, 1985.*

7. *"First management period new turf acres" means turf acres that came into existence or were substantially commenced after December 31, 1984 and before January 1, 1992, but that was not substantially commenced prior to January 1, 1985.*

8. *"Golf course" means a turf-related facility used for playing golf with a minimum of nine holes and including any practice areas.*

9. *"Hole" means a component of a golf course consisting at a minimum of a tee and a green. A practice area or driving range is not a hole.*

10. *"Landscape watering" means the application of water from any source, including effluent, to a water-intensive landscaped area, a low water use landscaped area, or revegetation acres within a turf-related facility.*

11. *"Low water use landscaped area" means an area of land of at least one acre in aggregate, which is an integral part of a turf-related facility, which is watered by a permanent water application system and that is planted primarily with plants listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list. Mature vegetation planted in a low water use landscaped area must cover at least 50 percent of the area.*

12. *"Newly turfed area" means, for a calendar year, an area of land planted with a warm-season grass species that was not planted with a warm-season grass species during the preceding calendar year.*

13. *"Overseeded area" means, for a calendar year, an area of land planted with any cool-season grass species that grows over a dormant warm-season grass species during the fall-winter period.*

14. *"Post-1991 acres" means a water-intensive landscaped area or a low water use landscaped area that was neither in existence nor was substantially commenced as of December 31, 1991.*

15. *"Pre-1985 acres" means a water-intensive landscaped area or a low water use landscaped area that was either in existence or was substantially commenced as of December 31, 1984.*

16. *"Substantially commenced" means that all pre-construction permits and approvals required by federal, state, or local governments have been obtained or substantial capital investment has been made in the physical on-site construction.*

17. *"Total cemetery area" means an area of land being used for cemetery-related purposes, including any area of land covered by grave markers or by cemetery-related buildings, walks, pathways, and landscaping, but not including roads, parking lots, and any areas of land being held for future expansion of the cemetery.*

18. *"Turf acres" means an area of land that is watered with permanent water application system and planted primarily with plants not listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list.*

19. *"Turf-related facility" means any facility, including cemeteries, golf courses, parks, schools, or common areas within housing developments, with a water-intensive landscaped area of 10 or more acres. Turf-related facilities include, but are not limited to, those facilities listed in Appendix 6A.*

20. *"Water-intensive landscaped area" means, for a calendar year, the turf acres and the water surface acres within a turf-related facility.*

21. *"Water surface acres" means the total surface area of all bodies of water that are an integral part of the water-intensive landscaped area of a turf-related facility. Bodies of water used primarily for swimming purposes are not an integral part of the water-intensive landscaped area of a turf-related facility.*

6-302. Conservation Requirements for Turf-Related Facilities

A. Maximum Annual Water Allotment

Beginning with calendar year 2002 or the calendar year in which landscape watering commences, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility shall not withdraw, divert, or receive water for landscape watering purposes at the facility during a calendar year in an amount that exceeds the turf-related facility's maximum annual water allotment for the year as calculated in section 6-303.

B. Conservation Plan

No later than January 1, 2002 or 180 days after receiving official notice of conservation requirements, whichever occurs later, an industrial user who uses water at a turf-related facility shall have prepared a conservation plan for the facility that contains an accurate and detailed description of the conservation technologies, including management practices, that are applied at the facility when water is used for landscape watering purposes. The industrial user shall maintain the conservation plan until the first compliance date for any substitute requirement in the Fourth Management Plan.

C. Limiting Water-Intensive Landscaped Area

1. *Beginning on January 1, 2002 or upon commencement of landscape watering, whichever occurs later, and continuing until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility that is not a cemetery or a golf course shall design, construct, and maintain the grounds of the facility in a manner that minimizes the water-intensive landscaped area of the facility consistent with the use of the facility. All of the facility's water-intensive landscaping shall be planted in those areas directly associated with the turf facility's primary purposes.*

2. *Beginning on January 1, 2002 or upon commencement of landscape watering, whichever occurs later, and continuing until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility that is a cemetery shall limit the water-intensive landscaped area of post-1991 acres so that no more than 75 percent of the total cemetery area within the post-1991 acres is planted with plants not listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list, unless the post-1991 acres are an expansion of the cemetery onto contiguous land that was under the same ownership as the cemetery as of December 31, 1984.*

6-303. Calculation of Maximum Annual Water Allotment for Turf-Related Facilities

A. For each calendar year, the maximum annual water allotment for a turf-related facility shall be calculated by multiplying the number of acres in existence within the facility during the calendar year in each of the categories listed in Table 6-4 by the application rates listed in Table 6-4 and then adding together the products plus any allotment additions as determined under subsection B of this section. The maximum annual water allotment is subject to the conditions and restrictions set forth in Table 6-4.

TABLE 6-4
APPLICATION RATES, CONDITIONS, AND ALLOTMENT RESTRICTIONS
FOR TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA
From 2002 until the first compliance date for any substitute conservation requirement in the Fourth Management Plan

For All Facilities:	***Application Rate: (acre-feet per acre per calendar year)***
1. Pre-1985 Acres	
Turf Acres	*4.6*
Water Surface Acres	*5.8*
Low Water Use Landscaped Area	*1.5*
Conditions and Restrictions: *The allotment shall be calculated using the highest number of Pre-1985 acres in existence within the facility during any single calendar year after 1979.*	
2. First Management Period New Acres	
Turf Acres	*4.6*
Water Surface Acres	*5.8*
Low Water Use Landscaped Area	*1.5*
Conditions and Restrictions: *a. For golf courses, the allotment for first management period new turf acres shall not exceed an amount calculated by multiplying the number of holes within those acres by 23 acre-feet of water, plus any allotment additions as determined under subsection B of this section.* *b. For golf courses, if the first management period new turf acres exceed an area calculated by multiplying the number of holes within those acres by five acres, the allotment for all bodies of water within the first management period new acres not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact shall not exceed an amount calculated by multiplying the number of holes within the first management period new turf acres by 0.8056 acre-foot of water, plus any allotment additions as determined under subsection B of this section. For purposes of this paragraph, any body of water allowed under an interim water use permit pursuant to A.R.S. § 45-133 shall be deemed to be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact if the body of water will be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact after the permit expires.*	
3. Post-1991 Acres	
Turf Acres	*4.6*
Total Water Surface Area	*5.8*
Low Water Use Landscaped Area	*1.5*

TABLE 6-4
APPLICATION RATES, CONDITIONS, AND ALLOTMENT RESTRICTIONS FOR TURF-RELATED FACILITIES TUCSON ACTIVE MANAGEMENT AREA
From 2002 until the first compliance date for any substitute conservation requirement in the Fourth Management Plan

For All Facilities:	***Application Rate: (acre-feet per acre per calendar year)***
Conditions and Restrictions: *a. For golf courses, the total allotment for post-1991 turf acres and post-1991 low water use landscaped area shall not exceed an amount calculated by multiplying the number of holes within the post-1991 acres by 23 acre-feet of water, plus any allotment additions as determined under subsection B of this section.* *b. For golf courses, the allotment for all bodies of water within the post-1991 acres not filled and refilled entirely with direct use effluent or effluent recovered within the area of impact shall not exceed an amount calculated by multiplying the number of holes within the post-1991 acres by 0.8056 acre-foot of water, plus any allotment additions as determined under subsection B of this section. For purposes of this paragraph, any body of water allowed under an interim water use permit pursuant to A.R.S. § 45-133 shall be deemed to be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact if the body of water will be filled and refilled entirely with direct use effluent or effluent recovered within the area of impact after the permit expires.*	

B. Allotment Additions

1. Newly Turfed Area Establishment Addition

For any year in which a warm-season turfgrass species is planted at a turf-related facility, the facility shall receive an allotment addition of 1.0 acre-foot of water per acre of newly turfed area. For golf courses, the newly turfed area establishment addition shall not exceed an amount calculated by multiplying the number of holes present within the newly turfed area by 5 acre-feet of water.

2. Revegetation Addition

The owner or operator of a turf-related facility may apply to the director for an allotment addition to revegetate areas within or around the facility after initial construction or renovation of new acres. The director may allow up to an additional 1.5 acre-feet of water per acre for up to three years if the following conditions apply to the acres for which the revegetation addition is sought:

a. The plants that are planted within the revegetation area are listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list, or were adapted to the site prior to construction;

b. The aggregate area to be watered exceeds one acre and has at least 50 percent vegetative cover at maturity;

c. An allotment is not provided for the revegetation area under section 6-303.A; and

d. All of the water applied to the revegetation area is measured and reported as part of the total water use of the facility.

3. Body of Water Fill and Refill Addition

a. A turf-related facility shall receive a one-time body of water fill allotment addition equal to the volume of water used for the initial filling of any new body of water added after January 1, 2002 within the facility. The facility shall receive the allotment addition only for the calendar year in which the body of water is filled.

b. If a body of water at a turf-related facility is drained or partially drained to allow for repairs to reduce water losses the owner or operator of the facility may apply to the director for an addition to the facility's maximum annual water allotment in the amount of water necessary to refill the body of water. The director shall grant the allotment addition if the director determines that drainage of the body of water was necessary to allow for repairs to reduce water losses. The facility shall receive the allotment addition only for the calendar year in which the body of water is filled.

4. Leaching Allotment Addition

The owner or operation of a turf-related facility may apply to the director for an allotment addition for leaching purposes. The director shall approve the application if the water supply used for landscape watering at the facility contains at least 1000 milligrams per liter of total dissolved solids. If the director approves an allotment

addition for leaching purposes, the director shall calculate the additional allotment as follows:

$$\textbf{Leaching Allotment Addition} = \left(\frac{1}{1 - \left(\frac{EC_w}{5EC_e - EC_w} \right)} - 1 \right) \times \frac{CU}{0.85}$$

Where: EC_w = *Electrical conductivity of water used*

EC_e = *Tolerance of the grass species grown to the soil salinity in electrical conductivity of the soil saturation extract*

CU = *Consumptive use requirement for the grass species*

Any allotment addition granted under this subsection shall remain in effect until the water supply used for landscape watering at the facility contains less than 1,000 milligrams per liter of total dissolved solids or until the first compliance date for the facility's conservation requirements in the Fourth Management Plan, whichever occurs first.

C. Combined Allotments for Contiguous Facilities

The maximum annual water allotments for contiguous turf-related facilities under one ownership or operation may be combined. All or a portion of the combined maximum water allotment may be applied to any part of the contiguous facilities.

D. *Nothing in this section shall be construed as authorizing use of more groundwater or surface water than may be used pursuant to any groundwater or appropriable water rights or permits associated with the use. Nor shall this section be construed as authorizing the use groundwater or surface water in any manner that violates Chapter 1 or Chapter 2 of Title 45, Arizona Revised Statutes.*

6-304. Compliance with Maximum Annual Water Allotment

A. Effluent Use Adjustment

For purposes of determining compliance with the maximum annual water allotment requirement, the director shall count each acre-foot of direct use effluent or effluent recovered within the area of impact used at the facility for landscape watering purposes during the calendar year as 0.7 acre-foot of water.

B. Flexibility Account

The director shall determine if a turf-related facility is in compliance with the maximum annual water allotment requirement through the maintenance of a flexibility account for the facility according to the following:

1. *Beginning with calendar year 2002 or the first full calendar year after the commencement of landscape watering, whichever is later, a flexibility account shall be established for a turf-related facility with a beginning balance of zero acre-feet.*

2. *Following each calendar year in which groundwater is withdrawn, diverted, or received for landscape watering purposes at the facility, the director shall adjust the turf-related facility's flexibility account as follows:*

    a. *Subtract the total volume of water from any source, including effluent, as adjusted under subsection A of this section, used by the facility for landscape watering purposes during that calendar year, from the facility's maximum annual water allotment for that year.*

    b. *If the result in subparagraph a of this paragraph is positive, credit the flexibility account by this volume.*

    c. *If the result in subparagraph a of this paragraph is negative, debit the flexibility account by this volume.*

3. *The account balance existing in a turf-related facility's flexibility account after the adjustment provided for in paragraph 2 of this subsection is made shall carry forward subject to the following limitations:*

    a. *The maximum positive account balance allowed in the flexibility account of a turf-related facility after any credits are registered pursuant to paragraph 2, subparagraph b of this subsection, shall be calculated by multiplying the facility's maximum annual water allotment for the calendar year for which the credits are registered by 0.2. If the account balance exceeds the maximum positive account balance after the credits are registered, the balance carried forward shall be equal to the maximum positive account balance.*

    b. *The maximum negative account balance allowed in the flexibility account of a turf-related facility after any debits are registered pursuant to paragraph 2, subparagraph c of this subsection, shall be calculated by multiplying the facility's maximum annual water allotment for the year for which the debits are registered by -0.2. If the account balance is less than the maximum negative account balance after the debits are registered, the balance carried forward shall be equal to the maximum negative account balance.*

C. Compliance Status

If the adjustment to a turf-related facility's flexibility account following a calendar year as provided for in subsection B, paragraph 2 of this section, causes the account to have a negative account balance less than the maximum negative account balance allowed in the flexibility account for the calendar year as calculated in paragraph 3, subparagraph b of this section, the industrial user who uses water at the facility is in violation of the facility's maximum annual water allotment for that calendar year in an amount equal to the difference between the facility's flexibility account balance and the maximum negative balance allowed in the facility's flexibility account.

6-305. Monitoring and Reporting Requirements

A. An industrial user who uses water at a turf-related facility that commences landscape watering within post-1991 acres after January 1, 2002 shall submit to the director documentation of the new acreage within the facility no later than 90 days after commencing landscape watering within the new acres or receiving notice of these conservation requirements, whichever is later. The scale of the submitted documents, extent of turf acres, water surface acres, and low water use landscaped area must clearly be shown. Documentation may consist of one or more of the following:

1. *As-built plans certified by a registered professional such a civil engineer, golf course designer, or landscape architect.*

2. *Aerial photography at a scale no smaller than 1"=200'.*

3. *A survey of the facility certified by a registered professional such a civil engineer or land surveyor.*

4. *Any other documentation upon approval by the director.*

B. For calendar year 2002 or the calendar year in which landscape watering commences, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user who uses water at a turf-related facility shall include in the annual report required by A.R.S. 45-632 the following information:

1. *The total quantity of water by source, disaggregated by each source, withdrawn, diverted, or received during the calendar year for landscape watering purposes at the facility, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

2. *The amount of effluent, disaggregated by direct use effluent, effluent recovered within the area of impact, and effluent recovered outside the area of impact, that was withdrawn, diverted or received during the calendar year for landscape watering purposes as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et. seq.*

3. *The number of acres of turf acres within the facility during the calendar year, not including newly turfed area.*

4. *The number of water surface acres within the facility during the calendar year.*

5. *The number of acres of low water use landscaped area within the facility during the calendar year.*

6. *The number of acres of newly turfed area within the facility during the calendar year.*

7. *The number of turf acres removed within the facility during the calendar year.*

8. *The number of water surface acres added or removed within the facility during the calendar year.*

9. *The number of acres of low water use landscaped area added or removed within the facility during the calendar year.*

10. *If the facility is a golf course, the length of the course as measured from the back of each tee ground furthest from the associated green, then down the center line of the hole to the center of the green.*

11. *The number of acres approved by the director for a revegetation addition pursuant to section 6-303, subsection B, within the facility during the calendar year.*

12. *The quantity of water used to fill or refill a body of water within the facility during the calendar year for which an allotment addition is sought pursuant to section 6-303, subsection B.*

13. *The number of acres of overseeded area within the facility during the calendar year.*

14. *If the facility is a golf course, the number of holes within the facility during the calendar year.*

15. *If the facility is a golf course, the number of holes added within newly turfed area during the calendar year.*

16. *An estimate of the quantity of water from any source, including effluent, used for each purpose other than landscape watering purposes at the facility during the reporting year. Any water used at the facility that is not measured separately from the water used for landscape watering shall be counted by the director as water used by the facility for landscape watering for purposes of calculating the compliance with the maximum annual water allotment.*

C. *A single annual report may be filed for contiguous turf-related facilities that are under the same ownership or operation if the allotments for the contiguous facilities are combined pursuant to section 6-303, subsection C. The annual report shall report water use and landscaped areas of the contiguous facilities as required in subsection B of this section.*

6.4 SAND AND GRAVEL FACILITIES

6.4.1 Introduction

Sand and gravel facilities regulated under the Third Management Plan are facilities that produce sand and gravel and use more than 100 acre-feet of water from any source in a calendar year. Sand and gravel facilities include the activities of mining aggregate, mixing concrete, and producing asphaltic concrete.

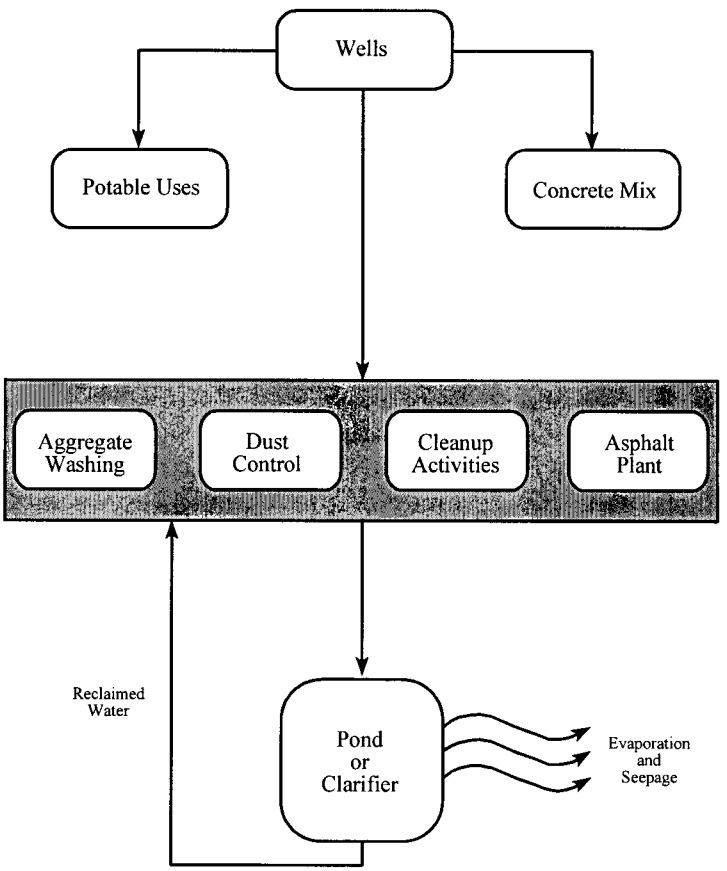
6.4.2 Water Use by Sand and Gravel Facilities

In the Tucson AMA, approximately 15 sand and gravel facilities are located along the banks of the Santa Cruz River or along older sand and gravel deposits in the Tucson, Green Valley, and Marana areas. These sand and gravel facilities pump groundwater pursuant to non-irrigation grandfathered rights or groundwater withdrawal permits. In 1995, sand and gravel facilities in the Tucson AMA held Type 1 and Type 2 non-irrigation grandfathered rights, and Type 2 mineral extraction rights and groundwater withdrawal permits with a combined annual allotment of around 17,000 acre-feet of groundwater.

Since adoption of the Second Management Plan, operators of sand and gravel operations have withdrawn between 2,300 acre-feet and 5,200 acre-feet of groundwater per year. It is projected that water use by sand and gravel facilities will grow commensurate with economic activity in the AMA, and will be approximately 7,000 acre-feet per year by 2025.

Sand and gravel facilities mine unconsolidated stream deposits to produce construction materials. The aggregate must be sorted according to grain size and washed to remove fine-grained particles. Aggregate washing accounts for the bulk of water use by sand and gravel facilities. In addition to using water for washing, water is used for the following purposes: (1) to produce ready-mix concrete, bricks, blocks, and asphaltic concrete; (2) to control dust; (3) to wash the outside of vehicles; (4) to wash the inside of mixer drums; (5) to wash other equipment; (6) to cool equipment; (7) to cool material; and (8) for domestic purposes. Figure 6-2 illustrates how water is cycled in a typical sand and gravel facility.

FIGURE 6-2
DIAGRAM OF WATERFLOW IN A TYPICAL SAND AND GRAVEL FACILITY



Most sand and gravel facilities recycle wash water using excavated pits called disposal ponds. Sediment-laden wash water is pumped or diverted into a pit or series of pits where sediment is allowed to settle out. After this sediment settles out, the water is recycled to the plant and used to wash more material. Water can also be pumped from the pond for dust control, truck washing, or other cleanup activities.

Geologic and hydrologic conditions at many facilities may result in a large amount of seepage loss incidentally returning to the aquifer from disposal ponds. Because most facilities are located along major riverbeds, depth to groundwater is usually relatively shallow. Some facilities even require dewatering to lower the water table to allow excavation to occur. A large portion of seepage loss may become a component of the groundwater pumped by sand and gravel facilities.

An alternative method of recycling wash water is the use of clarifiers. A clarifier is a device that accelerates the settling of sediment without creating the need for a large disposal pond. Chemical flocculants are usually used in conjunction with clarifiers to further enhance the removal of solid particles from the wash water.

Recycled water is not used for mixing concrete because the use of recycled water in the mixture may result in a product of inferior strength and quality. However, aggregate used in the concrete can be washed with recycled water without affecting concrete strength.

The ability of sand and gravel facilities to save water varies because of differences in geology, availability and cost of land and water, product demand and price, and other factors. It may therefore be economically feasible to use the latest commercially available conservation technology at some facilities but not at others.

Because recycled water can be used for most purposes at a sand and gravel facility, the maximum saving of water can occur in the recycling of wash water from aggregate washing and, to a lesser extent, the recycling of water used for wet scrubbers at asphalt plants.

There are a number of conservation techniques that may be employed to reduce the amount of water used to control dust raised by trucks traveling on haul roads. Binding agents, pavement, or other surface treatments may be used. Water uses for cleanup activities may be made more efficient by metering truck washing and by using alternative methods to clean truck mixer drums. Alternative methods can include the "rock out" method, which involves agitating rock inside the mixer drums for the purpose of cleaning excess concrete, or the use of chemical set-arresting agents, which prevent excess concrete from adhering to the mixer drums.

Sand and gravel facilities that have asphalt plants may have air emissions from the plant cleaned by either baghouses or wet scrubbers. Of these two methods, baghouses do not require water.

6.4.3 Program Development and Issues

The First Management Plan required sand and gravel facilities to recycle wash water using disposal ponds or clarifiers. This requirement ensures that sand and gravel facilities reduce their water use. The First Management Plan requirements were carried over into the second management period.

To identify the most economical conservation methods for each facility, sand and gravel facility operators were required during the second management period to evaluate specific water-saving methods and submit a conservation plan to the Department.

In addition to the conservation requirements identified in the First and Second Management Plans, there are a number of economically feasible ways water use for dust control and cleanup activities can be reduced. However, because conditions and characteristics at each facility vary, flexibility is needed to allow facility operators to select the requirements most appropriate for their facility.

6.4.4 Sand and Gravel Conservation Program

The First and Second Management Plan requirements for recycling wash water are included for the third management period because implementation of recycling improves water use efficiency. All sand and gravel operations can apply these techniques.

In addition to recycling wash water, sand and gravel facility operators must implement two additional conservation measures, one related to water used for dust control and the other related to cleanup activities. The facility operator must choose the conservation measure to be implemented in each category from a list of approved measures. The measures chosen must be the most appropriate for the facility for the third management period.

Similar to the Second Management Plan, sand and gravel operators will be required to evaluate specific water-saving methods and submit a conservation plan to the Department during the third management period. The conservation plan must be submitted to the director by January 1, 2002 or within 180 days after notification of the conservation requirements, whichever is later.

Implementation of water conservation practices or technologies can result in increased profits. Sand and gravel facility operators should analyze conservation methods to identify those that will result in a positive economic return. Operators will be required to perform an economic feasibility analysis of three potential conservation practices: disposal pond surface area reduction, use of clarifiers, and the use of an alternative water supply to groundwater. The following potential costs and savings may be analyzed in the economic feasibility analysis:

- Labor (including planning, construction, operation, maintenance, and management time);
- Equipment (values amortized over the projected life of the equipment);
- Land value (including value of mineral reserves);
- Water costs (including pumping costs, well maintenance, and withdrawal taxes);
- Costs for chemicals and raw materials;
- Fuel or energy costs;
- Industrial wastewater disposal costs;
- Changes in revenue caused by changing production rate, minimizing "down-time," or increasing the size of reserves; and
- Regulatory permitting costs.

6.4.5 Future Directions

In the Tucson AMA, sand and gravel facilities use water pursuant to non-irrigation grandfathered rights or groundwater withdrawal permits. Other potential water sources include CAP water, effluent and remediated groundwater. None of these sources are currently being used by the sand and gravel industry in the AMA. Effluent discharged to the Santa Cruz River could be a viable water source for facilities located along the River downgradient from the regional wastewater treatment plants. Secondary effluent is inexpensive and potentially available for use by sand and gravel facilities with the exception of use in concrete production. Several facilities are located in proximity to the CAP canal in the Marana area, however CAP water is significantly more expensive than groundwater. Groundwater pumping costs are low for most sand and gravel facility operators because the facilities are generally located where groundwater levels are close to the land surface. Incentives for use of effluent or CAP water could be considered in the Fourth Management Plan to address the potential for these facilities to use non-groundwater supplies.

6.4.6 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Sand and Gravel Facilities

6-401. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-402 through 6-404 of this chapter shall have the following meanings:

1. *"Alternative water supply" means a water source other than groundwater of drinking water quality.*

2. *"Sand and gravel facility" means a facility that produces sand and gravel and that uses more than 100 acre-feet of water from any source per calendar year. For purposes of this definition, the annual water use shall include all water used by the facility regardless of the nature of the use.*

3. *"Rock out method" means agitating rock inside concrete truck mixer drums for the purpose of cleaning excess concrete from the drums.*

4. *"Wash water" means water used for washing or sorting sand, gravel, or other aggregates.*

6-402. Conservation Requirements

A. Standard Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation requirements in the Fourth Management Plan, an industrial user who uses water at a sand and gravel facility shall comply with the following conservation requirements:

1. *If sufficient land area for construction and operation of disposal ponds is available at a reasonable price, the industrial user shall construct disposal ponds at the sand and gravel facility. All wash water, all water used for wet scrubbers at asphalt plants, all runoff from cleanup operations and all drainage from sand and gravel piles shall be discharged or diverted into the disposal ponds unless prohibited by state or federal environmental regulations. The disposal ponds shall contain a barge pump or sump pump of sufficient capacity, together with any necessary additional equipment, to assure the maximum reclamation of the water. The water shall be reclaimed and reused at the sand and gravel facility unless prohibited by state or federal regulations.*

2. *If sufficient land area for the construction and operation of disposal ponds is not available at a reasonable price, clarifiers shall be used at the sand and gravel facility for reclaiming wash water, all water used for wet scrubbers at asphalt plants, runoff from cleanup operations and all drainage from sand and gravel piles. The clarifiers shall be designed and operated to assure the maximum reclamation of water. The water shall be reclaimed and reused at the sand and gravel facility unless prohibited by state or federal regulations.*

3. *At least one of the following techniques or technologies designed to reduce water use for dust control shall be implemented at the sand and gravel facility:*

   a. *The placement of binding agents on all haul roads;*

   b. *The paving of all haul roads;*

   c. *The placement of recycled asphalt on all haul roads;*

   d. *The placement of medium sized aggregate or "pea gravel" on all haul roads; or*

   e. *A technology or technique designed to reduce water use for dust control not included in subparagraphs a through d of this paragraph that demonstrates water savings equivalent to any of the technologies or techniques listed in subparagraphs a through d, and that has been approved by the director.*

   The industrial user shall have sole discretion in determining whether to implement more than one of the above technologies.

4. *At least one of the following techniques or technologies designed to reduce water use for cleaning shall be implemented at the sand and gravel facility:*

   a. *Use of metered timers for truck washing and other cleanup activities;*

   b. *Use of the "rock out method" of cleaning concrete from truck mixer drums;*

   c. *Use of concrete set-arresting agent chemical applications to clean concrete from truck mixer drums; or*

   d. *A technology or technique designed to reduce water use for cleaning that is not included in subparagraphs a through c of this paragraph that demonstrates water savings equivalent to any of the measures listed in subparagraphs a through c and that has been approved by the director.*

   The industrial user shall have sole discretion in determining whether to implement more than one of the above technologies.

B. Substitute Conservation Requirements

1. *An industrial user who uses water at a sand and gravel facility may apply to the director to use conservation technologies other than the standard conservation requirements prescribed in subsection A of this section. The director may approve the use of substitute conservation technologies if both of the following apply:*

   a. *The industrial user has submitted a detailed description of the proposed substitute technologies and the water savings that can be achieved by the use of those technologies, and;*

   b. *The director determines that the proposed substitute conservation technologies will result in a water savings equal to or greater than the savings that would be achieved by the standard conservation requirements prescribed in section 6-402.*

2. *If the director approves an industrial user's request to use conservation technologies other than the standard conservation requirements prescribed in subsection A of this section, the industrial user shall comply with the substitute conservation technologies approved by the director beginning on the date determined by the director and continuing until the first compliance date for any substitute conservation requirement in the Fourth Management Plan.*

C. Conservation Plan

Not later than January 1, 2002 or within 180 days after receiving notice of these conservation requirements, whichever is later, an industrial user who uses water at a sand and gravel facility, including an industrial user who acquires ownership of an existing sand and gravel facility after January 1, 2002, shall submit to the director a plan to improve the efficiency of water use at the facility on a form provided by the director. The plan shall analyze the economic feasibility of implementing all of the following at the facility:

1. *Disposal pond surface area reduction;*

2. *The use of clarifiers for recycling water;*

3. *Use of an alternative water supply if such a supply is available within a one mile radius of the facility.*

6-403. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which the sand and gravel facility first commences using water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user who uses water at a sand and gravel facility shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The quantity of water reclaimed from disposal ponds or clarifiers during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

2. *The quantity of water from any source, including effluent, supplied to the wash plant during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

3. *The quantity of water from any source, including effluent, supplied to the asphalt plant during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

4. *The aggregate surface area of any disposal ponds.*

5. *The average depth of any disposal ponds.*

6. *The estimated quantity of water from any source, including effluent, used during the calendar year for:*

a. *Industrial process purposes. Water used for industrial process purposes includes water used for sanitary waste disposal but does not include water used for cooling and cleaning purposes.*

b. *Non-domestic cooling purposes.*

c. *Non-domestic cleaning purposes. Water use for non-domestic purposes includes truck washing, truck mixer drum washing, or other non-domestic cleaning purposes.*

d. *Road dust control.*

e. *Landscape watering.*

f. *Other purposes.*

7. *The tonnage of material washed during the calendar year.*

6.5 METAL MINING FACILITIES

6.5.1 Introduction

The Department regulates mining facilities that mine and process metallic ores and use or have the potential to use more than 500 acre-feet of water per year. Copper and molybdenum are the primary products of the metal mines of the Tucson AMA. Two mining techniques are used in the AMA. Open-pit mining followed by milling and flotation is the predominant mining technique. Leaching followed by solvent extraction and electrowinning (SX/EW) is also used at some locations. Water is used in almost all steps of the mining process. Conservation requirements address specific process steps to reduce overall water use.

6.5.2 Water Use by Metal Mining Facilities

Metal mines used 41,359 acre-feet of groundwater in 1995, constituting the largest industrial water use sector in the AMA. Currently mines have rights to pump around 62,000 acre-feet of groundwater per year pursuant to Type 1 and Type 2 non-irrigation grandfathered rights and groundwater withdrawal permits. Withdrawals vary substantially from year to year due to fluctuations in copper market conditions.

Four metal mines are currently operating in the Tucson AMA: Cyprus Sierrita, Cyprus Twin Buttes, ASARCO Mission, and ASARCO Silver Bell. Cyprus Sierrita and Cyprus Twin Buttes Mines are located 26 miles south of Tucson, west of the Sahuarita/Green Valley area (Figure 6-3). The Cyprus Sierrita and Twin Buttes mines hold groundwater rights and permits totaling 37,382 acre-feet per year. In 1995, the two mines used a total of 27,390 acre-feet of groundwater pursuant to those rights and permits (Table 6-5).

TABLE 6-5
1995 GROUNDWATER RIGHTS AND WITHDRAWAL PERMITS AND 1987 TO 1995 GROUNDWATER WITHDRAWALS FROM METAL MINES TUCSON ACTIVE MANAGEMENT AREA

	ASARCO Mission Complex		ASARCO Silver Bell Mine	Cyprus Sierrita Mine	Cyprus Twin Buttes Mine
Volume of Groundwater Rights and Permits (AF/YR)	17,585		6,703	23,366	14,016
1995 Withdrawals (AF)	10,771[1]	2,982[2]	217	22,066	5,324
1994 Withdrawals (AF)	10,038[1]	4,684[2]	182	22,674	5,946
1993 Withdrawals (AF)	9,440[1]	4,250[2]	80	18,880	6,071
1992 Withdrawals (AF)	9,023[1]	3,705[2]	234	16,953	6,920
1991 Withdrawals (AF)	7,925[1]	1,466[2]	437	23,900	5,877
1990 Withdrawals (AF)	7,086[1]	1,428[2]	406	17,887	5,636
1989 Withdrawals (AF)	6,876[1]	2007[2]	532	18,684	3,499
1988 Withdrawals (AF)	6,034[1]	821[2]	262	16,566	205
1987 Withdrawals (AF)	5,322[1]	732[2]	351	15,838	60

AF = acre-feet
[1] Withdrawals from ASARCO property that are pursuant to groundwater right and permits
[2] Withdrawals from San Xavier District for ASARCO use that are not pursuant to groundwater rights and permits

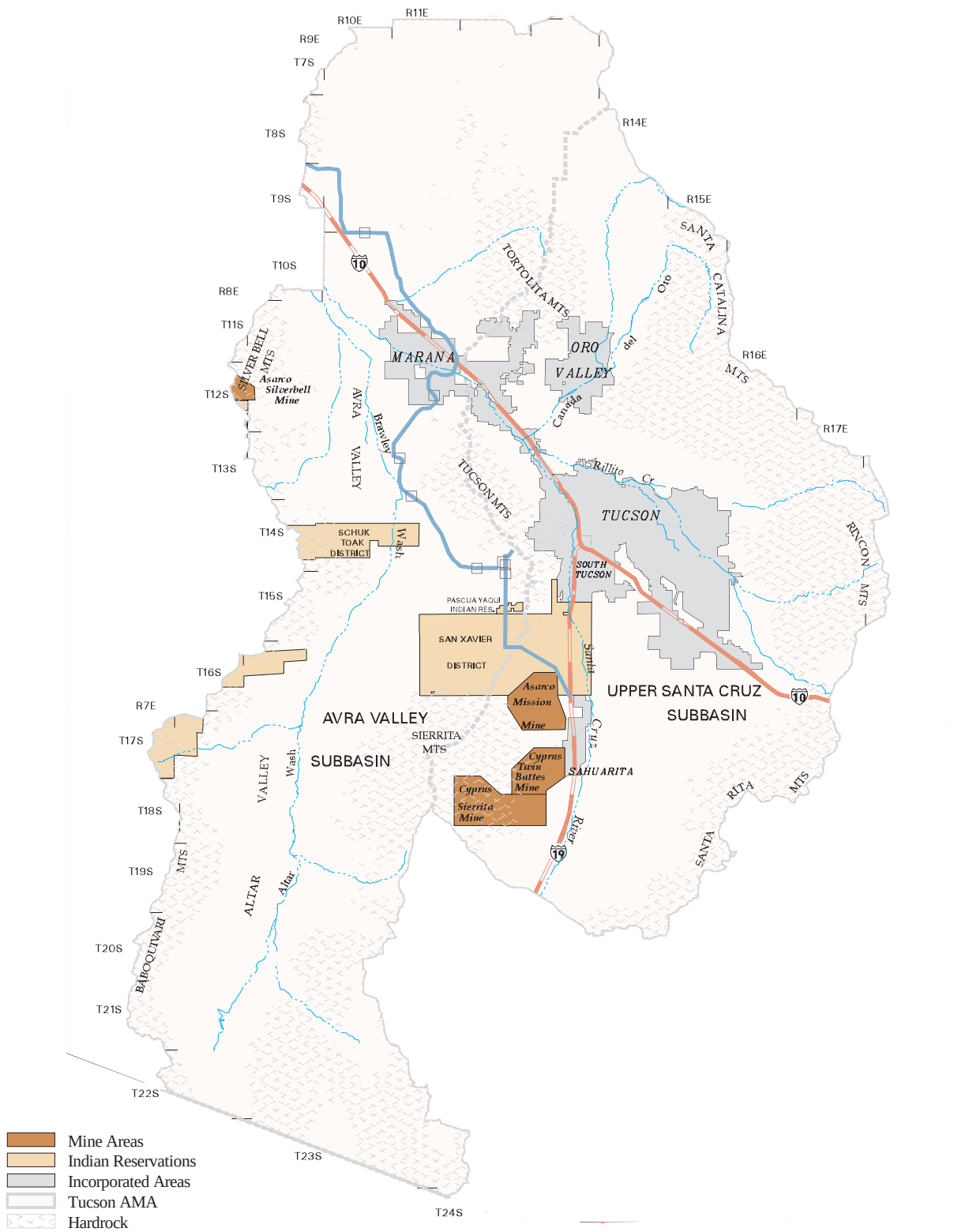


Figure 6- 3

Approximate Areas of Metal Mines

ORIGINAL SOURCE

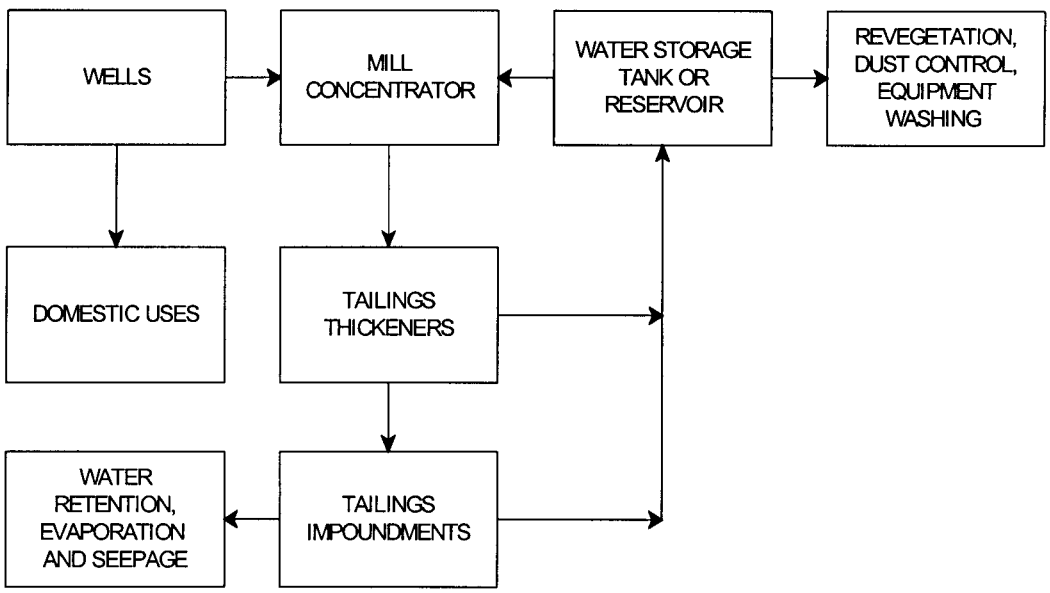
Arizona Department of Water Resources
Geographic Information System

ASARCO Mission Complex is located 16 miles south of Tucson, along the southern boundary of the San Xavier District of the Tohono O'odham Nation. It holds groundwater rights and permits totaling 17,585 acre-feet per year. In 1995, this facility used 10,771 acre-feet of groundwater pursuant to its rights and permits. In addition, the Mission Complex pumped 2,982 acre-feet of groundwater from the San Xavier District by agreement with the District, bringing total groundwater use to 13,753 acre-feet. Groundwater withdrawn from the District is not subject to state reporting and management requirements for groundwater.

ASARCO Silver Bell Mine is in the northwest portion of the Tucson AMA and straddles the Tucson and Pinal AMAs. Because the mine's production wells are located east of the facility within the Tucson AMA boundary, water use at the entire facility is regulated by the Tucson AMA. Silver Bell Mine used only 217 acre-feet of groundwater in 1995, but has constructed a new SX/EW plant at the site that will lead to increased copper production and water use. It holds groundwater rights and permits totaling 6,703 acre-feet per year.

Open-pit mining followed by milling and flotation steps is widely used to recover copper and molybdenum from metallic ore in Tucson AMA mines. Figure 6-4 is a simplified diagram of water flow at a typical copper mine using a mill and flotation process. In the mill concentrator, water is added to ore that is crushed and milled to a powder-like form. The crushed ore/water mixture is discharged into a series of flotation cells where the copper and molybdenum-bearing minerals are physically removed. This flotation is accomplished by adding chemicals to the mixture that cause the valuable minerals to float to the surface of the tanks where they are skimmed off and recovered.

FIGURE 6-4
DIAGRAM OF WATER FLOW IN A TYPICAL COPPER MINE USING A MILL AND FLOTATION PROCESS TO RECOVER COPPER



The milled rock material remaining in the mill flotation cells is moved to large thickener tanks where solids are allowed to settle to the bottom. After the solids settle, water is recovered from the top of the thickener tanks and recycled back to the mill concentrator. The thickened slurry of water and solids that settles to the bottom of the thickener tanks is known as tailings. Tailings are transported via pipeline from the bottom of the thickener tanks to tailings impoundments for final disposal. Groundwater can be conserved in the tailings transport process by maintaining the tailings slurry at a high density, by transporting tailings in smooth high density polyethylene piping to reduce friction loss in the pipes, and by pumping tailings to the tailings impoundments rather than gravity-feeding them.

Once transported, the tailings slurry is distributed on the surface of the tailings impoundment through spigots arrayed around the perimeter of the impoundment. The solid tailings settle to the bottom of the tailings impoundment leaving standing water in "stilling basins." This water is "decanted" or skimmed off using decant towers or barge pumps then returned to the mill concentrator for reuse. Evaporation from tailings impoundments is the largest consumptive use of water by the mines. Evaporation can be reduced by carefully managing tailings deposition to minimize the surface area of stilling basins and by installing multiple decant towers when possible, to decant water more quickly.

Some water is permanently retained in the fine-grained tailings material deposited in the impoundments. The amount of water retained in subsurface tailings is a function of the fine-grained texture of this material and is largely beyond the control of mine operators. Water also seeps out below the tailing impoundments. This seepage can be reduced by depositing fine-grained tailings (slimes) on top of native soils before delivering full tailings loads to these areas.

In addition to open-pit mining techniques, copper-bearing minerals can be leached at land surface from some types of ore-bearing rocks. Surface leaching is conducted by distributing a dilute solution of sulfuric acid over ore-bearing rocks that have been heaped or dumped on native bedrock. This solution is typically applied using a sprinkler system, resulting in some evaporative water loss. Drip lines can also be used to apply water in some cases. As the solution slowly passes through the ore-bearing rock, copper minerals are dissolved. Copper-rich water (leachate) is then collected from the bottom of the leach pile. Leachate is piped to an SX/EW facility for recovery of the copper. At this facility, the copper is transferred from the leach solution to a rich electrolyte solution then transported to vats where an electrical current draws copper out of solution onto solid copper plates. The leach solution left after the copper is removed is re-acidified and returned to the leach piles for reuse, thus conserving water use in the leach circuit. Water use may be further reduced by converting, if feasible, to delivery methods other than sprinkler systems.

An innovative form of leaching that has recently come into use is known as "in situ" or "in place" mining. This process uses an injection well to introduce a dilute solution of sulfuric acid into subsurface fractures in copper-bearing rock. As the solution circulates in the fractures, copper is dissolved. The copper-rich solution is recovered using extraction wells arranged around the injection well. At the surface, the copper-rich solution is piped to an SX/EW plant where the copper is extracted from the solution. The acid/water solution is continuously recycled through the copper deposit and the SX/EW plant, minimizing water use. In situ mining has been successfully conducted on a pilot scale in the Pinal AMA. If proven to be economically successful, in situ mining may be used in full-scale commercial mining operations in the future.

Leaching followed by an SX/EW process uses less water to produce copper than the flotation process. However, only selected types of ore will yield copper using leaching processes. The majority of ores in Tucson AMA mines must be recovered using open pit mining and the flotation process. Other water uses at metal mines include dust control, equipment washing, revegetation of tailings, and domestic needs.

Mineral output at Tucson AMA metal mines has recovered in recent years. The mining industry is expected to continue to operate in the AMA, with a slight increase in water use. It is projected that total groundwater withdrawals by metal mines will be 47,500 acre-feet per year by 2025.

6.5.3 Program Development and Issues

First Management Plan requirements for metal mines largely reflected mining practices in place at the time the regulations were written. Key requirements for metal mining facilities included:

- Transport tailings at a minimum average density of 40 percent solids by weight
- Reduce leakage from tailings impoundments by compacting tailings up slope from the free water surface in impoundments or by installing interceptor wells
- Manage tailings impoundments to minimize free water surface, maximize water depth, create stilling basins, and recover decant water
- Recover and recycle tailings impoundment water
- Cap abandoned tailings impoundments to minimize water used for dust control
- Comply with monitoring and reporting requirements

The First Management Plan also required mining facilities built after 1984 to achieve the greatest feasible tailings density, install any new wells so they would intercept tailings seepage, and equip any new tailings facilities with decant towers and interceptor wells to reclaim water from tailings impoundments and intercept seepage. In the First Management Plan, facilities could apply for alternative conservation programs or obtain temporary stays from conservation requirements.

First Management Plan requirements were modified in the Second Management Plan to require tailings densities of 45 percent for mines in operation by the end of 1984 and 50 percent for mines that went into operation after 1984. In addition, all mines were required to prepare long-range conservation plans in which they were to evaluate the feasibility of increasing tailings density to 55 percent, using alternative water sources, reducing tailings evaporation, and minimizing water use for dust control.

While water is actively recycled at area metal mines, there is some potential for additional groundwater conservation. This potential is addressed in the Third Management Plan with increased tailings density requirements and the addition of a menu of conservation strategies. Requirements have also been updated to reflect current mining practices and to integrate water conservation regulations with other environmental requirements.

Each 1 percent increase in the tailings density achieved during transport to tailings impoundments results in 500 to 800 acre-feet of water savings per year at the large open pit mines in the Tucson AMA. Improved conservation technologies have enabled mines to achieve tailings densities ranging from 46 to 52 percent at various portions of their facilities. In the Third Management Plan, tailings density requirements for mining facilities in operation by the end of 1984 have been increased from the Second Management Plan annual average density requirement of 45 percent to a three-year running average of 48 percent. This change reflects the increasing ability of the mines to maintain higher tailings transport densities. Lower densities will be temporarily allowed in cases where, because of equipment malfunctions or due to the density of ore being mined, the 48 percent densities cannot be achieved. Mines that began operation after 1984 are required to achieve an average annual tailings density of 50 percent.

In the Third Management Plan, the 50 percent tailings density requirement for mines that began operation after 1984 has been linked to construction of new mill concentrator facilities because constraints at the mill concentrator and thickeners largely control the maximum density that can be achieved in tailings transport. Conservation plan requirements for mines have shifted emphasis from providing site evaluation data to analyzing the latest available conservation technologies consistent with reasonable economic return.

Stilling basins are areas of free-standing water created in tailings impoundments when the solids in deposited tailings settle out. The Second Management Plan required that mining facilities manage tailings impoundments to minimize free water surface, maximize water depth, and create stilling basins. Third Management Plan specifications have been simplified to require that stilling basins be created and that their surface area be minimized.

To reduce seepage underneath tailings impoundments, the First and Second Management Plans required that impoundments be "preslimed" with fine-grained tailings and that these preslimed deposits be compacted. Because freshly deposited tailing slimes cannot support the weight of compaction equipment, Third Management Plan requirements have been modified to require facilities to preslime without compaction. An alternative to presliming is to install interceptor wells downgradient from each tailings impoundment to intercept seepage water from the impoundment.

To address further conservation potential at the mines, the Third Management Plan requires mining facilities to implement three additional conservation measures from a list of eight measures. These measures address aspects of tailings impoundment management, piping material, leach water delivery, dust control, site drainage, and revegetation.

The Second Management Plan requirement that wells constructed at mining facilities built after 1984 be placed to intercept the maximum possible amount of seepage has been deleted in the Third Management Plan because new wells may be needed to replace existing wells, to pump water from remote well fields, or to supply potable water. These needs may not be compatible with maximizing seepage interception. Facilities are required to use alternative water supplies to the extent practicable to minimize pumping of groundwater of drinking water quality. Alternative water supplies may include the use of groundwater supplies that do not meet drinking water standards. Additionally, facilities may use either decant towers or pumps to recover water and are required to minimize seepage from tailings impoundments.

In the Third Management Plan, surface leach operations and in situ leaching facilities are required to minimize water use to the extent practicable. In addition, a provision has been added in the Third Management Plan to address possible overlaps or conflicts between water conservation requirements and other environmental regulations. In determining compliance with mine conservation requirements, the director must ensure this compliance does not result in violating other local, state, or federal environmental regulations. Environmental regulations may include Best Available Demonstrated Control Technologies specified by the Arizona Department of Environmental Quality in their mine Aquifer Protection Permit requirements, mine closure requirements specified in Aquifer Protection Permits, mine closure requirements specified in the Mine Reclamation Act, air quality standards, federal Clean Water Act provisions, and others.

6.5.4 Metal Mine Conservation Program

Third Management Plan requirements for metal mines include the following provisions:

- Transport tailings at an average density of 48 percent solids by weight over a three-year running average at pre-1985 mines and at an average annual density of 50 percent at facilities built after 1984
- Reduce water loss from tailings impoundments by depositing tailings up slope from the free water surface in impoundments to reduce seepage or by installing interceptor wells down gradient of impoundments to intercept seepage at pre-1985 mines
- Manage tailings impoundments to minimize the free water surface of stilling basins and recover decant water
- Recover and recycle tailings impoundment water
- Cap abandoned tailings impoundments to minimize water used for dust control

- Minimize water use in leaching processes
- Implement three of eight specified additional conservation techniques
- Comply with monitoring and reporting requirements

In the third management period, metal mines will be required to evaluate water conservation practices and technologies that may be implemented at their facility and submit these evaluations to the Department in a long-range conservation plan.

6.5.5 Non-Regulatory Efforts

A study funded by the Department and by a Tucson AMA Conservation Assistance Grant was conducted by a consultant to determine the potential for additional groundwater conservation and the potential to use CAP water at Tucson area metal mines (Southwest Ground-water Consultants, Inc., 1997 *Conservation and CAP Use Potential of Tucson AMA Mines.* Prepared for the Arizona Department of Water Resources, Tucson AMA). In addition to providing data for development of the Third Management Plan conservation requirements for the mines, the results of the study have stimulated a more extensive and informed dialog between the mines, communities, and water suppliers on issues related to CAP conversion.

The mines currently rely entirely on groundwater for their water supply. Use of renewable supplies at Tucson AMA metal mines is likely to be limited to the use of CAP water because of the great distance between the mines and the large municipal effluent sources in Tucson. Use of CAP water by the mines is theoretically possible because the CAP delivery pipeline terminates at Pima Mine Road in the vicinity of ASARCO's Mission Mine (Figure 6-3). However, because the mines have sufficient groundwater rights to support planned mining activities well into the future, conversion to CAP water may need to be subsidized by other water users.

To make conversion to CAP water feasible, a number of issues would need to be addressed and resolved including finding a CAP source, constructing distribution lines to the mines, addressing the interruptability of the CAP supply, and addressing the impacts of CAP water quality on mineral extraction processes. The consultant's report addresses these issues and estimates costs for possible conversions. The Department continues to encourage conversion to renewable supplies by the mines due to the large volume of groundwater projected to be used and the potential acceptability of alternative sources.

6.5.6 Future Directions

The potential for additional groundwater conservation is somewhat limited at mines due to the current level of conservation and recycling being practiced and the need to continue to transport and dispose of tailings. Conversion to CAP water offers the best alternative to continued large scale groundwater use. Establishing meaningful incentives for such a conversion, facilitating communication and cooperation between possible partners, and continuing to add to the information base about CAP options are tasks the Department can undertake to improve the likelihood of conversion. The AMA has begun work on these efforts through its participation in regional recharge planning efforts. The potential for use of CAP water at mines through groundwater savings arrangements was one of a number of recharge approaches evaluated in this planning effort. The AMA has funded a study of the feasibility of delivering CAP water to mines and other potential users in the Sahuarita/Green Valley area. The Upper Santa Cruz Water Users Group is likely to use the information from the feasibility study as a basis for further exploration of the feasibility of funding and constructing a pipeline system to convey CAP water from the CAP canal terminus to water users in the Sahuarita-Green Valley area.

6.5.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Metal Mining Facilities

6-501. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases shall have the following meanings:

1. *"Abandoned tailings impoundment" means a tailings impoundment that the owner/operator of a metal mining facility does not plan to use for additional disposal of tailings.*

2. *"Alternative water supply" means a water source other than groundwater of drinking water quality.*

3. *"Decant water" means water removed from the stilling basin of a tailings impoundment either by gravity flow into a decant tower or by pumping.*

4. *"Heap and dump leaching" means the extraction of minerals using acid solutions applied to metallic ores that have been removed from their original location and heaped or dumped in a new location.*

5. *"In situ leaching" means the extraction of metallic ores using acid leaching of ores that are not moved from their original natural location.*

6. *"In situ leaching sites" mean those portions of metal mining facilities at which in situ leaching and associated copper recovery operations occur, including surface applications of acid leaching solutions and deep well injection of acid leaching solutions.*

7. *"Large-scale metal mining and processing facility" means an industrial facility at which mining and processing of metallic ores is conducted and that uses or has the potential to use more than 500 acre-feet of water per reporting year. For the purposes of this definition, the annual water use or potential annual water use includes all water from any source, including effluent, used or projected to be used within or by the facility, regardless of the nature of the use.*

8. *"Mill concentrator" means the structure at open-pit metal mines within which metallic ore is crushed and the flotation process is used to remove minerals.*

9. *"Mill circuit" means the flow of water used in the process of crushing ore, recovering copper at the mill concentrator, and transporting and disposing of tailings, and includes recovery of water at the tailings impoundments for reuse in the mill concentrator.*

10. *"Post-1984 metal mining facility" means either:*

    a. *A large-scale metal mining and processing facility that does not qualify as a pre-1985 metal mining facility, including any expanded or modified portion of the facility, or*

    b. *Any expanded or modified portion of a pre-1985 metal mining facility if the expansion or modification includes one or more new tailings impoundments, new mill circuits,*

or new leaching facilities, and was not substantially commenced as of December 31, 1984.

11. *"Pre-1985 metal mining facility" means a large-scale metal mining and processing facility at which the mining and processing of metallic ores was occurring as of December 31, 1984, or that was substantially commenced as of December 31, 1984, and includes any expanded or modified portion of such a facility if the expansion or modification includes one or more new tailings impoundments, new mill concentrator circuits, or new wells, and was substantially commenced as of December 31, 1984.*

12. *"Seepage water" means water that has infiltrated from tailings impoundments into the material underlying the tailings impoundments.*

13. *"Substantially commenced as of December 31, 1984" means, with regard to the construction, expansion, or modification of a large-scale metal mining and processing facility, that the owner or operator of the facility had obtained all pre-construction permits and approvals required by federal, state, or local governments for the construction, expansion, or modification of the facility by December 31, 1984, or had made a substantial capital investment in the physical on-site construction of the project in the 12 months prior to December 31, 1984.*

14. *"Tailings" mean the slurry of water and fine-grained waste rock material remaining after minerals have been removed in the mill concentrator and excess water has been recovered and returned to the mill concentrator.*

15. *"Tailings impoundment" means the final disposal site for tailings generated in the milling circuit.*

6-502. Conservation Requirements for Pre-1985 Metal Mining Facilities

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a pre-1985 metal mining facility shall comply with the following requirements:

A. Management of Tailings Density

The industrial user shall transport tailings to the tailings impoundment area at the maximum density possible consistent with reasonable economic return; but, beginning with calender year 2002, the average density of the tailings during transport shall be 48 percent solids by weight or greater during the period consisting of the reporting year and the previous two years. The director may reduce the density required for a period of time determined by the director if the industrial user demonstrates that, due to the shut down of ore processing or tailings transport equipment or due to the density of ore being mined, a three-year average density of 48 percent or greater cannot be achieved.

B. Management of Presliming/Interceptor Wells

The industrial user shall comply with one of the following:

1. *Deposit a layer of tailings immediately up-slope from the free water level in each tailings impoundment. The tailings layer shall be 12 inches or more in thickness and shall minimize soil surface permeability.*

2. *Drill interceptor wells down-gradient from each tailings impoundment. The interceptor wells shall be designed, located and operated in such a manner as to intercept the maximum amount of seepage water possible from each tailings impoundment. Water recovered from the interceptor wells shall be reused at the mining facility.*

C. Management of Water in Tailings Impoundments

The industrial user shall minimize the free water surface area in each tailings impoundment by complying with all of the following:

1. *Manipulate tailings that have been disposed of in a tailings impoundment, and manage new disposal of tailings in an impoundment, to create stilling basins that increase the rate of recovery of decant water from the stilling basins, and to minimize the free water surface area of stilling basins.*

2. *Use decant towers, barge pumps, or sump pumps to recycle water from each tailings impoundment back to the mill concentrator.*

3. *Expand decant tower barge pumping capacity where necessary to increase the capacity to recycle water from each tailings impoundment back to the mill concentrator.*

4. *Use, to the maximum extent possible, tailings impoundment water, rather than pumping additional groundwater.*

D. Capping Abandoned Tailings Impoundments

The industrial user shall cap each abandoned tailings impoundment in a manner that minimizes the quantity of water used for dust control purposes and/or revegetation.

E. Heap and Dump Leaching

The industrial user shall apply water to heap and dump leaching operations in a manner that minimizes water use to the extent practicable, consistent with reasonable economic return.

F. Additional Conservation Measures

An industrial user who uses water at a metal mining facility shall comply with three of the following eight conservation measures at those portions of the facility that do not qualify as in situ leaching sites:

1. *When revegetating abandoned mine-related areas, utilize drought-tolerant vegetation.*

2. *Utilize multiple decant towers in single impoundments to increase decant rate.*

3. *Convert piping to high density polyethylene piping to increase density of transported tailings.*

4. *Harvest and reuse storm water runoff on site.*

5. *Reuse pit dewatering water.*

6. *Reduce evaporation from free-standing water surfaces in addition to evaporation reduction from stilling basins.*

7. *Reduce water used for dust control by reducing the number and extent of haul trips, using road binders, converting to conveyors for material transport, or using another dust control measure that reduces water use.*

8. *Reduce water used for delivery of acid/water solution for heap or dump leaching operations by using delivery methods that use less water than sprinkler delivery.*

6-503. Conservation Requirements for Post-1984 Metal Mining Facilities

Beginning on January 1, 2002 or upon commencement of operations at the facility, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a post-1984 metal mining facility shall comply with conservation requirements applicable to pre-1985 metal mining facilities as prescribed in section 6-502, subsections C through F, and the following additional requirements:

A. Management of Tailings Impoundments

The industrial user shall design and construct any post-1984 tailings impoundments to maximize recovery of water from the stilling basins and to minimize seepage water. Any interceptor wells down gradient of tailings impoundments shall be constructed to maximize recovery of seepage water.

B. Management of Tailings Density

The industrial user shall design, construct, and operate any post-1984 mill concentrators and their associated tailings transport systems to achieve the maximum tailings densities possible consistent with reasonable economic return, but the average annual density of tailings during transport shall not be less than 50 percent solids by weight.

C. Management of In Situ Leaching

The industrial user shall utilize water for in situ leaching in a manner that minimizes water use to the extent practicable, consistent with reasonable economic return.

6-504. Alternative Conservation Program

An industrial user who uses water at a metal mining facility may apply to the director to use conservation technologies other than the technologies prescribed in sections 6-502 and 6-503, whichever is applicable. The director may approve the use of alternative conservation technologies if the director determines that both of the following apply:

1. *The industrial user has filed a detailed description of the proposed alternative technologies and the water savings that can be achieved by the use of these technologies with the director.*

2. *The industrial user has demonstrated to the satisfaction of the director that the latest commercially available conservation technology consistent with reasonable economic return will be used.*

6-505. Modification of Conservation Requirements for Metal Mining Facilities

A. *An industrial user who uses water at a metal mining facility may apply to the director to modify conservation requirements prescribed in sections 6-502 and 6-503, whichever is applicable, for any year in which compliance with the conservation requirements would likely result in violation of any federal, state, or local environmental standards or regulations. To apply for a modification of conservation requirements, an industrial user shall submit a request in writing to the director that includes the following information:*

1. *Documentation describing the conservation requirement(s) for which compliance with this requirement is likely to result in violation of environmental standards, and the environmental standards that are likely to be violated.*

2. *The proposed modification to the conservation requirements.*

B. *The director shall grant a request for modification of conservation requirements if the director determines that compliance with the conservation requirements prescribed in sections 6-502 and 6-503, whichever is applicable, would likely result in a violation of any federal, state, or local environmental standards or regulations.*

6-506. Preparation of a Long-Range Conservation Plan for Metal Mining Facilities

By January 1, 2002 or three months prior to commencement of operations at the facility, whichever is later, an industrial user who uses water at a metal mining facility shall submit to the director a long-range water conservation plan that describes the existing or planned design, construction and operation of the facility, including a description of the ore type, method of mining, and method of metal extraction. The plan shall include an evaluation of the use of the latest commercially available conservation technology consistent with reasonable economic return. Prior to submitting the plan, the industrial user shall analyze the feasibility of applying the following conservation practices or technologies at the mine and shall report the results in the plan:

1. *Using alternative water sources for mining and metallurgical needs, including determining the source and volume of the alternative water sources being analyzed.*

2. *Reducing tailings impoundment evaporation through the application of the latest commercially available technologies for minimizing evaporation from the impoundments and through the application of improved tailings management.*

3. *Minimizing water use for dust suppression through the use of road binders, conveyors, paved haul roads, and other available dust control mechanisms.*

4. *Increasing tailings densities to 55 percent solids or greater by weight.*

The industrial user may include any additional conservation techniques or technologies in the plan. The plan shall include a schedule of the approximate dates for implementation of any conservation practices or technologies that the industrial user intends to implement.

6-507. Monitoring and Reporting Requirements for Metal Mining Facilities

A. Water Measurement and Reporting

For calendar year 2002 or the calendar year in which the facility commences operation, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a metal mining facility shall include in its annual report required by A.R.S. § 45-632 the following information:

1. *The quantity of water from any source, including effluent, used during the calendar year for each of the following purposes: dust control, tailings revegetation, domestic use, and transportation of tailings to tailings impoundments. The quantity of water used for dust control and tailings revegetation shall be separately measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq. The quantity of water used for domestic use and transportation of tailings to tailings impoundments may be estimated.*

2. *The quantity of make-up water from any source, including effluent, used during the calender year for each of the following purposes: equipment washing, leaching operations, and milling operations, as separately measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

3. *The quantity of water from any source, including effluent, reclaimed during the calendar year from each of the following: tailings impoundments and pit dewatering. These quantities shall be separately measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R-12-15-901, et seq.*

4. *The tons of ore milled during the calendar year.*

5. *The tons of ore stacked to heap and/or dump leach during the calendar year.*

6. *The tons of ore vat leached during the calendar year.*

7. *The tons of material mined during the calendar year.*

8. *The tons of mineral produced from mill circuits and from leach circuits during the calendar year.*

9. *The average gallons of water consumed per ton of mineral produced during the calendar year.*

10. *The average percentage of solids by weight in tailings transported to the tailings impoundments during the calendar year and in each of the previous two years.*

11. *The average annual depth of water at the deepest portion of the stilling basin(s).*

12. *Copies of aerial photos of tailings impoundments, with scale indicated, for use by the Department in determining the wetted surface area of the tailings impoundments.*

13. *A description of the additional conservation measures applied at the metal mining facility as prescribed in section 6-502, subsection F.*

B. Contiguous Facilities

A single annual report may be filed for a pre-1985 metal mining facility and a post-1984 metal mining facility that are contiguous and owned by the same owner. The combined operations of the metal mining facilities shall be described pursuant to reporting requirements specified in subsection A of this section.

6.6 LARGE-SCALE POWER PLANTS

6.6.1 Introduction

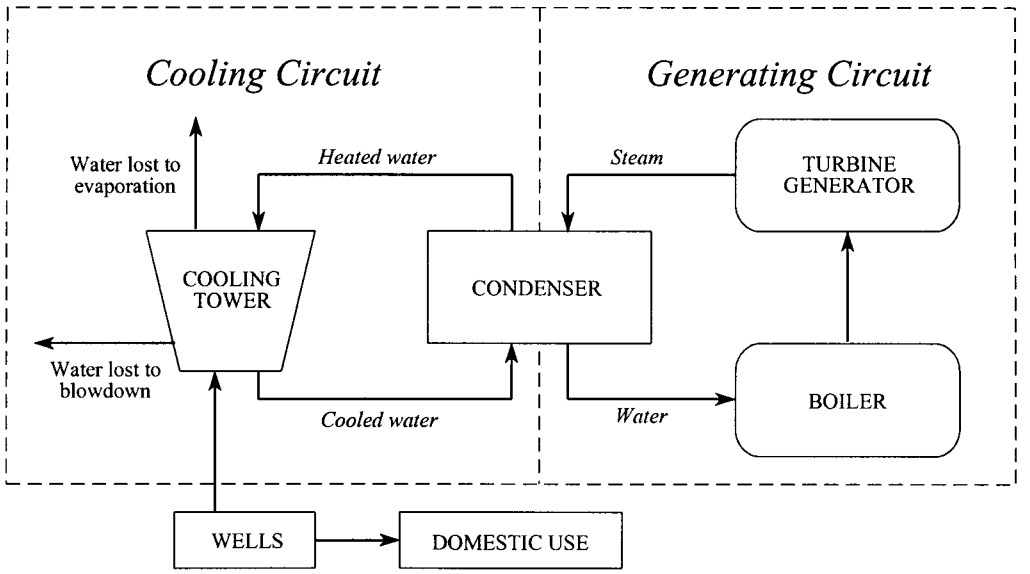
The Department regulates power plants that produce or are designed to produce more than 25 megawatts of electricity. The electric power industry uses cooling towers to dissipate excess heat that builds up in the electrical generation process. The major consumptive use of water at these facilities is evaporation from cooling towers. Because of the large volume of water used in towers, conservation requirements for the electric power industry require facilities to achieve a high level of efficiency in cooling tower operation.

6.6.2 Water Use by Large-Scale Power Plants

The electric power industry in the Tucson AMA currently holds water rights to over 10,000 acre-feet of groundwater per year pursuant to Type 2 non-irrigation grandfathered rights limited to use for electric power generation. Two large-scale power plants currently operate in the Tucson AMA. The Tucson Electric Power plant operates year round and is located at Irvington Road and Interstate 10 in the southeast area of Tucson. Water use averaged 1,700 acre-feet per year at this plant between 1987 and 1995. It is projected that water demand at this plant will reach 1,900 acre-feet per year by the year 2025. An Arizona Public Service plant is located in the northwest portion of the AMA near Picacho. This peaking plant operates only during high demand periods in the hotter months of the year. Water use averaged 350 acre-feet per year at this plant between 1987 and 1995, and is projected to reach 600 acre-feet per year by 2025. Groundwater used by these plants is not projected to parallel population growth because the electric power needed to meet increasing demand is likely to be imported, rather than generated within the AMA.

Most electric power plants have two water use circuits, referred to as the generating circuit and the cooling circuit. Figure 6-5 illustrates water flow in a typical electrical power plant. In the generating circuit, water is heated in the boiler to form steam that turns the turbines. The turbines in turn drive the generators that create electricity. The steam must be cooled and condensed into water before being recycled back to the boiler. The conversion of water to steam and back to water in the generating circuit is completed in a closed system, so water is efficiently recycled with little loss.

FIGURE 6-5
DIAGRAM OF WATER FLOW IN A TYPICAL POWER PLANT



At the condenser, heat is transferred from the steam in the generating circuit to the cooled water in the cooling circuit. Because this heat exchange occurs through the walls of the condenser piping, water in the two circuits does not mix. The heated water in the cooling circuit is pumped to a cooling tower where it is cooled by evaporation. The cooled water is then recirculated back to the condenser. Evaporation losses in the cooling tower constitute the main consumptive use of water at large-scale power plants. As a portion of the cooling circuit water evaporates in the cooling tower, dissolved minerals become more concentrated in the remaining water. Due to the high mineral concentrations, corrosion, mineral deposition, and biological fouling can result and can lead to reduced cooling efficiency and equipment damage. Use of chemical treatments can prolong water use in a tower, but periodically, mineral-laden water must be discharged or "blown down" to prevent minerals from precipitating on equipment. Replacement water, known as "make-up water," is added to replace water lost to evaporation and blowdown.

The "cycles of concentration" or "concentration ratio" achieved in a tower indicate how efficiently water is being used. Cooling towers that are consistently operated at higher cycles of concentration consume less water than towers consistently operated at lower cycles of concentration. Cycles of concentration can be determined by dividing the concentration of a constituent in the blowdown water by the concentration of this same constituent in the make-up water. Total dissolved solids content is one commonly used constituent for calculating the cycles of concentration. For example, if the total dissolved solids concentration in blowdown water is 1,500 milligrams per liter (mg/l), and the total dissolved solids content of make-up water is 300 mg/l, the tower is operating at 5 cycles of concentration. Cycles of concentration can also be calculated using electrical conductivity measurements, water volumes, and other conservative mineral constituents (mineral constituents whose concentrations are not altered by precipitation, loss to the atmosphere, or the addition of treatment chemicals).

6.6.3 Program Development and Issues

Conservation requirements for the electric power industry were generally the same in the First and Second Management Plans. Facilities in operation by the end of 1984 were required to reach 7 cycles of concentration in cooling towers before blowing down water. Facilities that went into operation after 1984 were required to reach 15 cycles of concentration. For large-scale power facilities in operation by the end of 1984, achieving 7 cycles of concentration is a realistic ceiling on water use efficiency. Above 7 cycles of concentration, the potential for additional water savings decreases while the potential for equipment damage and the cost of chemical additives both increase. Large-scale power facilities can be designed to achieve 15 cycles of concentration, but the technology to accomplish this needs to be built into the plant from the outset and represents an additional expense.

Third Management Plan regulations keep the core requirements from earlier management periods with some modifications to address cooling tower operational time periods and periods of changing water quality. In the Third Management Plan, the cycles of concentration requirement has been revised to apply only when cooling towers are in full operational mode dissipating heat created during the generation of electricity. Some large-scale power plants generate electricity only during summer months when demand for electric power peaks. During non-generating months, compliance with the cycles of concentration requirements may not be possible because even though water is recirculated to keep tower surfaces wetted, tower evaporation fans are turned off to reduce electricity use. This reduces the normal rate of evaporation. When the recirculating water eventually becomes stagnant, it needs to be blown down even if 7 (or 15) cycles of concentration have not been reached.

Individual cooling towers are periodically shut down and rebuilt. New structural pieces may be installed in towers during this process. If chemically treated lumber is used, concentrations of arsenic, copper, or chromium can build up in tower water. This water needs to be discharged before these concentrations exceed environmental standards even if 7 (or 15) cycles of concentration have not been reached. As groundwater is withdrawn from greater depths, mineral and trace metal concentrations can increase. When

this groundwater is used to provide make-up water to cooling towers, concentrated minerals in the recirculating water can precipitate and cause equipment damage. There is also a potential for trace metals to build up in recirculating water and exceed sewer system discharge standards for Publicly-Owned Treatment Works or exceed National Pollutant Discharge Elimination System standards. In the Third Management Plan, the director may adjust the 7 (or 15) cycles of concentration requirement for cooling towers at large-scale power plants in cases where, because of leaching from new tower components, deterioration of make-up water supplies, or other reasons, facilities are likely to experience equipment damage or come into conflict with environmental discharge regulations if they comply with the cycles of concentration requirement. A facility must submit documentation of potential problems to support its request to have the cycles of concentration requirement reduced.

Use of effluent in cooling towers is encouraged as an alternative to groundwater use. The feasibility of this use depends on a number of factors including, among others, the availability of effluent, the volume and timing of water demand at the towers, water quality considerations, cost, any constraints on groundwater supplies, and site-specific factors such as other on-site uses for the effluent. The chemical composition of this renewable water source can vary seasonally and even daily depending on the quality, volume and source of wastewater flowing into wastewater treatment facilities. In the Third Management Plan, cooling towers at power plants are exempted from cycles of concentration requirements for the first 12 months in which effluent constitutes more than 50 percent of a tower's water supply. During this period, the power plant operator can collect data on the concentration and variability of constituents in the effluent-served cooling towers that may limit the cycles of concentration that can safely be reached and maintained. After the 12-month exemption period, the facility must either comply with the required cycles of concentration standards or propose an alternative cycles of concentration standard for effluent-served towers based on the data collected during that year.

Several additional changes have been made to the Third Management Plan to more accurately reflect facility operations. The definition of "continuous blowdown and make-up" has been revised to clarify that this term refers to continuous blowdown and make-up or frequent periodic blowdown and make-up of recirculating water. Monitoring and reporting requirements have been revised to allow total dissolved solids, other conservative mineral constituents, or electrical conductivity to be used to determine cycles of concentration. Monitoring and reporting requirements have also been revised to allow monitoring in time increments consistent with operational periods for cooling towers.

6.6.4 Large-Scale Power Plant Conservation Program

The Third Management Plan requires that power plants in operation as of the end of 1984 achieve an annual average of 7 cycles of concentration in cooling towers, while facilities that went into operation after 1984 are required to achieve an annual average of 15 cycles of concentration in their cooling towers. The cycles of concentration requirement applies only during periods when facilities are generating electricity and applies only to fully operational towers that are dissipating heat from the power generation process. In addition to achieving 7 (or 15) cycles of concentration, facilities must discharge blowdown water and add make-up water to cooling towers on a continuous basis and divert the maximum possible volume of on-site wastewater (other than blowdown water and sanitary wastewater) to the cooling process.

Facilities may be granted adjustments to their full cycles of concentration requirements in cases where, due to the quality of recirculating water, adhering to the 7 (or 15) cycles of concentration standard is likely to result in equipment damage or blowdown water exceeding environmental discharge standards. Cooling towers at power plants are exempted from cycles of concentration requirements during the first 12 months in which effluent constitutes more than 50 percent of tower water supply. After this period, facilities may request an adjustment to full cycles of concentration requirements for effluent-served towers based on the water quality of the effluent supply.

Facilities may apply to the director to use alternative conservation technologies in place of achieving 7 (or 15) cycles of concentration if the use of the proposed alternative technologies will result in equal or greater water savings. Facilities may also request a waiver from conservation requirements on the basis that cooling tower blowdown water is completely reused. Facilities must periodically measure and annually report blowdown water volumes, make-up water volumes, and the chemical concentration of blowdown and make-up water. In addition, facilities must report the amount of electricity generated, periods when they are not generating electricity, and the volume of water used for purposes other than electric power generation.

6.6.5 Non-Regulatory Efforts

Conservation assistance funds in the Tucson AMA are supporting a study of the tolerance of common landscape plants to cooling tower blowdown water from an electric power plant. The goal of this study is to determine whether landscapes can successfully be watered with blowdown water rather than groundwater. An experimental project in the Phoenix AMA uses cooling tower blowdown water from a large-scale power plant to grow halophytes (salt tolerant plants) that are being used to vegetate an urban wildlife refuge adjacent to the facility. Depending on the results of these studies, cooling tower blowdown water may be useful for replacing the use of groundwater to water existing vegetation at some locations.

6.6.6 Future Directions

In the Tucson AMA, large-scale power facilities are supplied by Type 2 non-irrigation grandfathered rights limited to use for electric power generation. Other potential water sources include CAP water and effluent, but neither of these are currently being used by the electric power industry in the AMA. The Third Management Plan includes a temporary exemption from the cycles of concentration requirements for towers using at least 50 percent effluent, with the option to adjust cycles of concentration requirements if needed to make long-term use of effluent viable. If this option is used by power plants during the third management period, the information gained can be used to direct research and regulatory directions in the fourth management period. Reuse of industrial wastewater in cooling towers and use of cooling tower blowdown water for landscape watering should continue to be examined to determine the advantages and constraints of these conservation strategies.

6.6.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Large-Scale Power Plants

6-601. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases shall have the following meanings:

1. *"Blowdown water" means water discharged from a cooling tower recirculating water stream to control the buildup of minerals or other impurities in the recirculating water.*

2. *"Conservative mineral constituent" means a component of recirculating water in a cooling tower, the concentration of which is not significantly modified by precipitation, loss to the atmosphere or the addition of treatment chemicals.*

3. *"Continuous blowdown and make-up" means patterns in cooling tower operation that include continuous blowdown and make-up or frequent periodic blowdown and make-up of recirculating water.*

4. *"Cycles of concentration" means the ratio of the concentration of total dissolved solids, other conservative mineral constituent or electrical conductivity in the blowdown water to the concentration of this same constituent or electrical conductivity in the make-up water.*

5. *"Effluent-served cooling tower" means a cooling tower served by a make-up water supply that on an annual average basis consists of 50 percent or more effluent.*

6. *"Fully operational cooling tower" means a cooling tower that is functioning to dissipate heat from a large-scale power plant that is generating electricity.*

7. *"Large-scale power plant" means an industrial facility that produces or is designed to produce more than 25 megawatts of electricity.*

8. *"Limiting constituent" means a chemical, physical, or biological constituent present in recirculating cooling tower water that, due to potential physical or biological factors or due to potential exceedence of any federal, state, or local environmental standards upon discharge as blowdown, should not be allowed to accumulate in recirculating cooling tower water above a certain concentration.*

9. *"Make-up water" means the water added back into the cooling tower recirculating water stream to replace water lost to evaporation, blowdown, or other mechanisms of water loss.*

10. *"Post-1984 power plant" means either:*

    a. *A large-scale power plant that does not qualify as a pre-1985 power plant and includes any expanded or modified portion of the power plant if the expansion or modification includes the construction or modification of one or more cooling towers; or*

b. Any expanded or modified portion of a pre-1985 power plant if the expansion or modification includes the construction or modification of one or more cooling towers and was not substantially commenced as of December 31, 1984.

11. "Pre-1985 power plant" means a large-scale power plant that either produced electric power as of December 31, 1984 or was substantially commenced as of December 31, 1984 and includes any expanded or modified portion of such a power plant if the expansion or modification was substantially commenced as of December 31, 1984 and included the modification or construction of one or more cooling towers.

12. "Substantially commenced as of December 31, 1984" means, with regard to the construction, expansion, or modification of a large-scale power plant, that all preconstruction permits and approvals required by federal, state, or local governments for the construction, expansion, or modification of the plant were obtained by December 31, 1984, or that a substantial capital investment in the physical on-site construction of the project was made within the 12 months prior to December 31, 1984.

6-602. Conservation Requirements for Pre-1985 Power Plants

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a pre-1985 power plant shall comply with the following requirements:

1. An annual average of 7 or more cycles of concentration shall be achieved at fully operational cooling towers during periods when the power plant is generating electricity.

2. Blowdown water shall be discharged on a continuous basis, and make-up water shall be provided on a continuous basis.

3. The maximum amount of wastewater feasible, excluding blowdown water and sanitary wastewater, shall be diverted to the cooling process.

6-603. Conservation Requirements for Post-1984 Power Plants

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user who uses water at a post-1984 power plant shall comply with the following requirements:

1. An annual average of 15 or more cycles of concentration shall be achieved at fully operational cooling towers during periods when the power plant is generating electricity.

2. Blowdown water shall be discharged on a continuous basis, and make-up water shall be provided on a continuous basis.

3. The maximum amount of wastewater feasible, excluding blowdown water and sanitary wastewater, shall be diverted to the cooling process.

6-604. Cycles of Concentration Adjustment Due to the Quality of Recirculating Water

A. An industrial user who uses water at a large-scale power plant may apply to the director for an adjustment to the cycles of concentration requirements set forth in section 6-602 or section

6-603, whichever is applicable, if compliance with the cycles of concentration requirements would likely result in damage to cooling towers or associated equipment or exceedence of federal, state or local environmental discharge standards because of the quality of recirculating water. To apply for an adjustment to the cycles of concentration requirements based on recirculating water quality, an industrial user shall submit a request in writing to the director that includes the following information:

1. *Historic, current and projected water quality data for the relevant constituent(s).*

2. *Documentation describing the potential damage to cooling towers or associated equipment, or documentation of environmental standards that are likely to be exceeded, whichever applies.*

B. *The director shall grant the request if the director determines that compliance with the cycles of concentration requirements set forth in section 6-602 or section 6-603, whichever is applicable, would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the quality of recirculating water.*

6-605. Exemption and Cycles of Concentration Adjustment Due to the Quality of Effluent Make-up Water Supplies

A. *The cycles of concentration requirements set forth in sections 6-602 and 6-603 do not apply to any effluent-served cooling tower at a large-scale power plant during the first 12 consecutive months in which more than 50 percent of the water supplied to the cooling tower is effluent.*

B. *After the 12-month exemption period expires, the industrial user who uses water at the large-scale power plant may apply to the director for a cycles of concentration adjustment to lower the cycles of concentration requirement for the effluent-served cooling tower if compliance with the requirement would not be possible due to the presence of a limiting constituent in the effluent supplying the tower. To apply for an alternative cycles of concentration requirement to address such a limiting constituent, an industrial user shall submit a request in writing to the director that includes the following information:*

1. *The limiting constituent that is present in the effluent supplying the tower that results in the need to blow down a greater annual volume of water than that required in section 6-602 or section 6-603, whichever is applicable.*

2. *Documentation describing the concentration at which this limiting constituent should be blown down and the reason for the alternative blowdown level.*

The director shall grant the request if the director determines that the presence of a limiting constituent in the effluent supplying the cooling tower results in the need to blow down a greater annual volume of water than that required in section 6-602 or section 6-603, whichever is applicable. Any cycles of concentration adjustment granted pursuant to this paragraph shall apply only while the tower qualifies as an effluent-served cooling tower.

6-606. Alternative Conservation Program

An industrial user who uses water at a large-scale power plant may apply to the director to use conservation technologies other than those prescribed in section 6-602 or section 6-603,

whichever is applicable. The director shall approve the use of alternative conservation technologies if both of the following apply:

1. *The industrial user files with the director a detailed description of the proposed alternative technologies and the water savings that can be achieved by the use of the alternative technologies.*

2. *The director determines that the alternative conservation technologies will result in water savings equal to or greater than the savings that would be achieved by the applicable conservation technologies prescribed in section 6-602 or section 6-603.*

6-607. Waiver

A. *An industrial user who uses water at a large-scale power plant may apply to the director for a waiver of any applicable conservation requirement in section 6-602 or section 6-603 by submitting a detailed, long-term plan for beneficial reuse of 100 percent of blowdown water outside the cooling circuit, including an implementation schedule. Reuse of blowdown water includes the discharge of blowdown water into pipes, canals, or other means of conveyance if the discharged water is transported to another location at the plant or off the plant for reuse.*

B. *The director shall grant a waiver request if the director determines that implementation of the plan will result in the beneficial reuse of 100 percent of blowdown water outside the cooling circuit. If a waiver request is granted, the industrial user shall implement the plan in accordance with the implementation schedule submitted to and approved by the director.*

6-608. Monitoring and Reporting Requirements

A. *For calendar year 2002 or the calendar year in which water use first commences, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale power plant shall include in its annual report required by A.R.S. § 45-632 the following information:*

1. *Cooling capacity in tons of each cooling tower at the facility.*

2. *Frequency of use of each cooling tower at the facility.*

3. *Source of water providing make-up water to each cooling tower at the facility.*

4. *For each cooling tower at the facility that is exempt from cycles of concentration requirements pursuant to section 6-605, subsection A, or for which a cycles of concentration adjustment was granted pursuant to section 6-605, subsection B, the percentage of water served to the tower during the year that was effluent.*

5. *For all fully operational cooling towers subject to cycles of concentration requirements under section 6-602 or section 6-603:*

    a. *The total quantity of blowdown water discharged from the cooling towers for each month or partial month when the facility was generating electricity during the calendar year.*

b. The total quantity of make-up water used at cooling towers for each month or partial month when the facility was generating electricity during the calendar year.

c. The weighted average concentration of total dissolved solids or other conservative mineral constituent in make-up water and blowdown water at the cooling towers for each month or partial month when the facility was generating electricity during the calendar year, either:

1) Determined by direct analysis, or

2) Calculated based on average monthly electrical conductivity readings if the following conditions have been met: (a) correlations between electrical conductivity and total dissolved solids or between electrical conductivity and another conservative mineral constituent have been established over a period of one year or more in make-up and blowdown water and (b) documentation of these correlations has been provided to the director.

6. For each fully operational cooling tower that is exempt from cycles of concentration requirements pursuant to section 6-605, subsection A, or for which an adjusted cycles of concentration requirement was granted pursuant to section 6-604 or section 6-605, subsection B:

a. The total quantity of blowdown water discharged from the cooling tower for each month or partial month when the facility was generating electricity during the calendar year.

b. The total quantity of make-up water used at the cooling tower for each month or partial month when the facility was generating electricity during the calendar year.

c. The weighted average concentration of total dissolved solids or other conservative mineral constituent in make-up water and blowdown water at the cooling tower for each month or partial month when the facility was generating electricity during the calendar year, either:

1) Determined by direct analysis, or

2) Calculated based on average monthly electrical conductivity readings if the following conditions have been met: (a) correlations between electrical conductivity and total dissolved solids or between electrical conductivity and another conservative mineral constituent have been established over a period of one year or more in make-up and blowdown water and (b) documentation of these correlation has been provided to the director.

7. All time periods when the facility was not generating electricity.

8. The amount of electricity generated each month or each partial month when the facility was generating electricity during the calendar year.

9. The estimated quantity of water from any source, including effluent, used during the calendar year for each purpose other than electric power generation purposes.

B. *A single annual report shall be filed for a pre-1985 power plant and a post-1984 power plant that are contiguous and owned by the same owner. The report shall describe the combined operations of the pre-1985 and post-1984 power plants as required in subsection A of this section.*

C. *All water measurements required in this section shall be made with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et. seq.*

6.7 LARGE-SCALE COOLING FACILITIES

6.7.1 Introduction

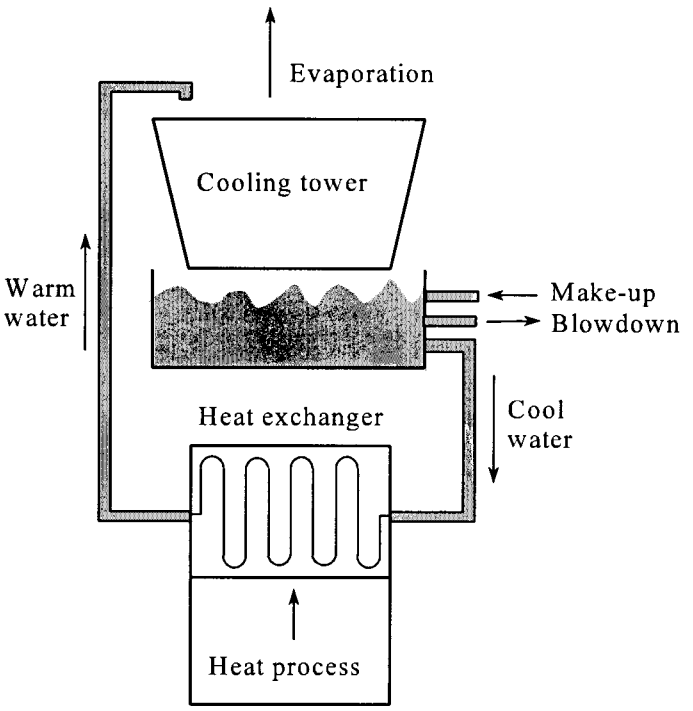
The purpose of cooling tower operation is to cool water that has absorbed the heat load of a heat-generating process. Cooling towers are present at a variety of commercial, industrial, and institutional facilities. Large-scale cooling facilities are defined as facilities with an aggregate cooling capacity of 1,000 tons or more. The minimum cooling unit which is added to create the aggregate total of 1,000 tons is 250 tons in size. Most large-scale cooling facilities are served by municipal water providers. These facilities are termed individual users. Water providers are responsible for the individual users' compliance with industrial conservation requirements unless they have notified the Department of the existence of the individual user as provided in section 5-111 of the Municipal Conservation Requirements (Chapter 5), in which case the individual user is responsible for compliance. Large-scale cooling facilities served by their own wells are regulated directly by the Department and are responsible for complying with industrial conservation requirements.

6.7.2 Water Use by Large-Scale Cooling Facilities

The main use of water in a cooling tower is to absorb heat from a heat-generating process and dissipate this heat through evaporation, as shown in Figure 6-6. Because a portion of the recirculating water is lost through evaporation, this is considered an "open" recirculating cooling loop.

The equipment served by a cooling tower varies from industry to industry, the most common is equipment used to reject heat from a large Heating, Ventilation, and Air Conditioning system (known as an HVAC system). Various equipment configurations are used to transfer heat from its source to the cooled water stream coming from the cooling tower. This transfer typically occurs inside a heat exchanger (Figure 6-6).

FIGURE 6-6
AN OPEN RECIRCULATING COOLING LOOP

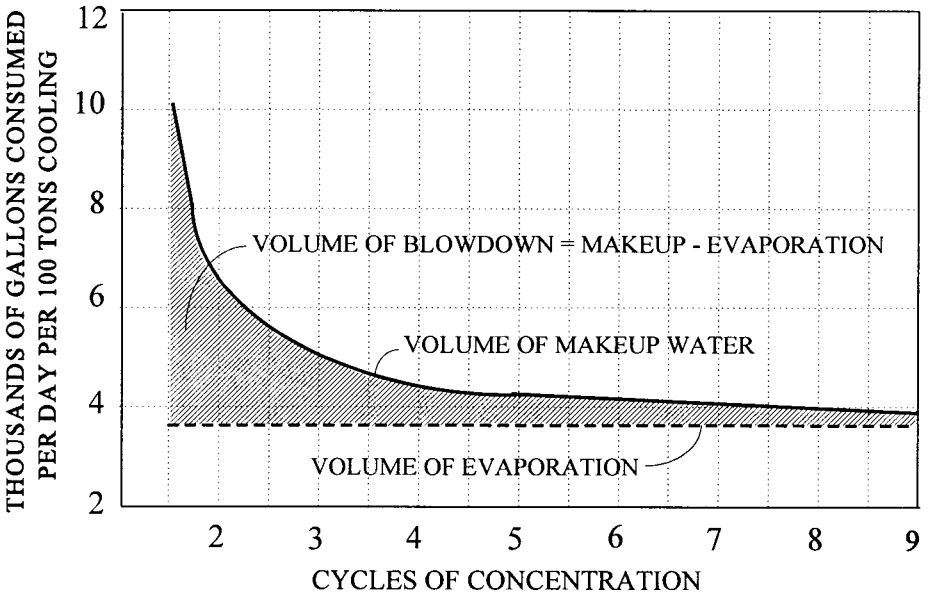


As a portion of cooling tower water evaporates, dissolved minerals become concentrated in the remaining water. Problems such as corrosion, mineral deposition, and biological fouling can result. These conditions reduce cooling efficiency and damage equipment. Chemical treatments including biocides, scale inhibitors, corrosion inhibitors, and addition of sulfuric acid can prolong the time mineral-laden water can safely be recirculated in towers. Mineral-laden water must periodically be discharged to prevent the excessive buildup of minerals and possible precipitation of these minerals onto equipment surfaces. This discharge is known as "blowdown." Replacement water, known as "make-up water" is added back to the tower's recirculating water stream to replace the water lost to evaporation and blowdown.

The "cycles of concentration" or "concentration ratio" achieved in a tower indicate how efficiently water is being used in the tower. Cycles of concentration can be determined by dividing the concentration of a constituent in the blowdown water by the concentration of this same constituent in the make-up water. The concentration of total dissolved solids, a measure of the overall dissolved mineral content in water, is one commonly used constituent for calculating the cycles of concentration. For example, if the total dissolved solids concentration in blowdown water is 1,500 mg/l and the total dissolved solids content of make-up water is 300 mg/l, the tower is operating at 5 cycles of concentration. Cycles of concentration can also be calculated using electrical conductivity measurements, water volumes, and other conservative constituents (mineral constituents whose concentrations are not altered by precipitation, loss to the atmosphere, or the addition of treatment chemicals).

Figure 6-7 illustrates the relationship between the cycles of concentration achieved in a tower and the volume of water lost through evaporation and blowdown and replaced by make-up water. At lower concentration cycles, the tower loses water through both evaporation and blowdown. At higher cycles of concentration, the rate of water consumption levels off until almost all water loss is due to evaporation. Evaporation cannot be reduced since this is the mechanism that provides the cooling function of the tower. However, blowdown can be minimized by operating the tower at optimal efficiency. The larger a tower is, the more water will be saved as the cycles of concentration increase.

FIGURE 6-7
RELATIONSHIP BETWEEN THE CYCLES OF CONCENTRATION AND THE AMOUNT OF WATER CONSUMED BY A COOLING TOWER



Cooling tower water use cannot be determined directly from water supply records because water supplies to large facilities serve a number of water needs besides cooling towers. In the absence of direct records, water use at cooling towers has been based on an estimation of the number, size and efficiency of towers in the Tucson AMA. Lists of large water customers served by municipal water providers were reviewed to locate hospitals, manufacturing plants, commercial buildings, department stores, grocery stores, schools, and other facilities with large cooling demands. Questionnaires were sent to these facilities to determine tower size and water use efficiency. Based on the lists of large water customers and survey results, it is estimated there are about 750 towers of all sizes in the Tucson AMA.

The size or cooling capacity of a tower is often described in units of tons. Cooling capacity tonnage indicates the rate at which the cooling tower can reject heat. Cooling tower capacities can range from as little as 50 tons to 1,000 tons or more. Large industrial or commercial facilities may have several large towers. As discussed in section 6.7.3, Third Management Plan regulations apply to facilities with a total cooling capacity of 1,000 tons or more. Based on the survey results, approximately 100 facilities may fit into this regulatory category. Assuming towers at these facilities average 1,000 tons in capacity and operate 24-hours a day at 3 cycles of concentration, they would use around 5,700 acre-feet of water annually. These estimates need to be confirmed with additional field data.

Future water use by regulated cooling towers will depend on the size and number of newly constructed facilities and the cycles of concentration achieved at all regulated towers. Assuming cooling tower construction parallels population growth, the number of towers in the Tucson AMA could double by 2025. At three cycles of concentration, facilities subject to Third Management Plan regulations could use 11,400 acre-feet by 2025.

6.7.3 Program Development and Issues

There were no conservation requirements in the First Management Plan for cooling towers other than for towers serving the electric power industry (section 6.6 of this chapter). Beginning in the Second Management Plan, regulations went into effect for "new large cooling users," defined as facilities with an aggregate tower capacity in excess of 250 tons that went into operation after January 1, 1990. Cooling towers at facilities in this category were required to achieve a concentration of 2,000 mg/l of total dissolved solids in recirculating water before blowing it down. The cutoff date of January 1, 1990 was intended to focus on new facilities with cooling towers, which could be identified as they established hook-ups with water providers. This identification process has proved to be difficult, and a complete list of facilities subject to Second Management Plan requirements has not been developed.

The Third Management Plan includes several changes intended to increase the effectiveness of conservation requirements for cooling towers. The facilities subject to regulation have been expanded from "new" facilities to facilities of all ages, because cooling technology has not changed significantly over time, and age alone does not preclude towers at facilities from achieving water use efficiency. At the same time, the size of regulated facilities has been shifted upwards to include only those facilities with an aggregate cooling capacity of 1,000 tons or more. In determining the aggregate cooling capacity of a facility, only cooling towers that are 250 tons or more in size are considered and only towers of this size or larger have specific blowdown requirements. This size cutoff excludes small capacity towers at which it may not be cost effective to conduct monitoring and install chemical feed equipment. Eliminating the January 1, 1990 cutoff date increases the number of facilities subject to regulation and increases the potential water savings. Identifying facilities subject to Third Management Plan requirements should be facilitated by concentrating on larger scale industries, commercial buildings, and institutions that need 1,000 tons or more of cooling capacity.

In the Second Management Plan, facilities were required to achieve a recirculating water concentration of 2,000 mg/l of total dissolved solids in cooling towers before blowing down. Blowdown standards in the Third Management Plan have been shifted from total dissolved solids to silica- and hardness-based standards. While the concentration of total dissolved solids is relatively easy to estimate using electrical conductivity as a surrogate and the 2,000 mg/l cutoff level addresses to some extent the water quality variations in make-up water supplies, silica and total hardness are more useful as indicators of the maximum concentration cycles that can safely be achieved in a tower. Silica can build up in recirculating water and damage equipment by precipitating a layer of "glass" inside piping. This silica layer reduces heat transfer and requires expensive repairs. The total hardness of water is a measure of the presence of calcium and magnesium salts, which can precipitate to form scale inside cooling towers and associated piping.

The purpose of Third Management Plan regulations is to effectively move large-scale cooling facilities toward more water conserving management practices while operating within a range that safely avoids mineral precipitation in cooling towers and associated piping. As required in the Code, conservation requirements for industrial users must be based on the use of the latest commercially available conservation technology consistent with reasonable economic return. Conservation requirements in the Third Management Plan focus on standards that can be achieved using conventional chemical treatment to extend cycles of concentration in cooling towers. This is the most efficient proven conservation technology currently available without major capital outlays. Several new commercially available technologies for tower operation and maintenance are available but have drawbacks because they are unproven technologies, have high initial capital costs, or do not work efficiently at high desert temperatures.

In the Third Management Plan, large-scale cooling facilities must achieve concentrations of either 120 mg/l of silica or 1,200 mg/l of total hardness, whichever is reached first, before blowing down the recirculating water from towers with 250 tons or more of cooling capacity. The solubility limit of silica in water is around 150 mg/l. Allowing facilities to discharge water when silica reaches 120 mg/l provides a margin of safety against costly equipment damage. The solubility limit of total hardness is a function of the chemical treatment used in a tower. Large cooling towers can generally operate safely at concentrations of around 1,200 mg/l total hardness in the recirculating water so this was selected as the Third Management Plan total hardness standard. Total hardness is typically expressed as an equivalent concentration of calcium carbonate ("hardness as calcium carbonate"), though both calcium and magnesium salts are included in this expression.

Third Management Plan cooling tower blowdown requirements apply only when towers are functioning to dissipate heat. Some towers are operated periodically based on seasonal or workload patterns, rather than being operated continuously. During periods when they are not dissipating heat, water may still need to be recirculated through towers to keep surfaces wetted, but evaporation fans may be turned off to reduce electricity use. This reduces the normal rate of evaporation. When the recirculating water becomes stagnant, it needs to be blown down whether or not blowdown standards have been met.

Use of effluent in cooling towers is encouraged as an alternative to groundwater use. The feasibility of this use depends on a number of factors including the availability of effluent, the volume and timing of water demand at the towers, water quality considerations, cost, any constraints on groundwater supplies, and site-specific factors such as other on-site uses for the effluent. The chemical composition of this renewable water source can vary seasonally and even daily depending on the quality, volume, and source of wastewater flowing into wastewater treatment facilities. In the Third Management Plan, a cooling tower at a large-scale cooling facility is exempt from cooling tower blowdown requirements for the first 12 months in which effluent constitutes 50 percent or more of the water supply to the tower. During this period, the facility operator will collect data on the concentration and variability of constituents in make-up water that may limit the cycles of concentration that can safely be reached and maintained. After the 12-month exemption period, the facility must either comply with the silica/total hardness blowdown standards for the tower or propose an alternative blowdown standard based on the data collected during that year.

For all facilities subject to Third Management Plan requirements, in cases where the build up of constituents other than silica or total hardness in cooling tower recirculating water is likely to result in damage to cooling towers or is likely to result in exceeding environmental discharge standards, facilities may apply to use an alternative blowdown standard.

6.7.4 Large-Scale Cooling Facility Conservation Program

Large-scale cooling facilities are facilities with a total cooling capacity of 1,000 tons or more. The following Third Management Plan conservation requirements apply to cooling towers that are located at large-scale cooling facilities and that have 250 tons or more of cooling capacity.

- Fully operational cooling towers with 250 tons or more of cooling capacity must achieve either 120 mg/l of silica or 1,200 mg/l of total hardness in recirculating water, whichever is reached first, before blowing down.
- If needed, a facility may apply for an alternative blowdown standard for any tower using effluent. During the initial 12-month period during which 50 percent or more of the water used by a tower is effluent, the tower is exempt from blowdown standards.
- If needed, a facility may apply for an alternative blowdown standard for any tower if compliance with blowdown requirements would likely result in damage or exceedence of environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness.
- Facilities must record monthly and report annually the volumes of tower make-up water and blowdown water and the concentrations of silica, total hardness or approved alternative constituent in both make-up water and blowdown water.

6.7.5 Non-Regulatory Efforts

To encourage water conservation in facilities of all sizes, a cooling tower training video has been prepared that describes how water can be conserved by improving the efficiency of tower maintenance. The video and an accompanying workbook were prepared through a Tucson AMA conservation assistance grant. Copies of this instructional set are available from the Department, water providers, Pima Community College, and the public library. Tower operators are asked to fill out a survey on their water use practices in conjunction with viewing the video and return the survey to the Department so data can be compiled on the size, water use patterns, and management practices of cooling towers in the AMA. This training material will be available throughout the third management period.

6.7.6 Future Directions

Identification of the regulated community and wide distribution of the cooling tower maintenance video and workbook are high priorities for the cooling tower program during the third management period. During this period, data on the number, size, and efficiency of cooling towers will be collected under both the regulatory and conservation assistance programs. Based on the collected data, the effectiveness of these programs will be determined. Fourth management period requirements may be adjusted accordingly. New cooling tower maintenance technologies will continue to be investigated and can be incorporated into future conservation requirements.

Experiences gained by facilities converting to effluent use in the third management period can be used to direct research and regulatory directions in the fourth management period. Reuse of industrial wastewater in cooling towers and use of cooling tower blowdown water for landscape watering should continue to be examined to determine the advantages and constraints of these approaches. The potential for future direct use of CAP water in the Tucson AMA has not been determined; but, if it occurs, the impacts on tower operation will be examined.

6.7.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Large-Scale Cooling Facilities

6-701. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases shall have the following meanings:

1. *"Blowdown water" means water discharged from a cooling tower recirculating water stream to control the buildup of minerals or other impurities in the recirculating water.*

2. *"Conservative mineral constituent" means a component of recirculating water in a cooling tower, the concentration of which is not significantly modified by precipitation, loss to the atmosphere, or the addition of treatment chemicals.*

3. *"Cycles of concentration" means the ratio of the concentration of a conservative mineral constituent or electrical conductivity in the blowdown water to the concentration of this same constituent or electrical conductivity in the make-up water.*

4. *"Effluent-served cooling tower"means a cooling tower served by a make-up water supply that on an annual average basis consists of 50 percent or more effluent.*

5. *"Fully operational cooling tower" means a cooling tower that is functioning to dissipate heat.*

6. *"Large-scale cooling facility" means a facility that has control over cooling operations with a total combined cooling capacity greater than or equal to 1,000 tons. For the purposes of this definition, the minimum cooling tower size that shall be used to determine total facility cooling capacity is 250 tons. A large-scale cooling facility does not include a large-scale power plant that utilizes cooling towers to dissipate heat.*

7. *"Large-scale power plant" means an industrial facility that produces or is designed to produce more than 25 megawatts of electricity.*

8. *"Limiting constituent" means a chemical, physical, or biological constituent present in recirculating cooling tower water that, due to potential physical or biological factors or due to potential exceedence of any federal, state, or local environmental standards upon discharge as blowdown, should not be allowed to accumulate in recirculating cooling tower water above a certain concentration.*

9. *"Make-up water" means the water added back into the cooling tower recirculating water stream to replace water lost to evaporation, blowdown, or other mechanisms of water loss.*

6-702. Conservation Requirements

A. Conservation Requirements

Beginning on January 1, 2002 or upon commencement of water use, whichever occurs later, and continuing thereafter until the first compliance date for any substitute conservation

requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale cooling facility shall comply with the following requirement:

Each fully operational cooling tower with greater than or equal to 250 tons of cooling capacity at the facility shall achieve a cycles of concentration level that results in blowdown water being discharged at an average annual minimum of either 120 mg/l silica or 1,200 mg/l total hardness, whichever is reached first.

B. Exemptions and Alternative Blowdown Standards

1. *The requirement set forth in subsection A of this section does not apply to a large-scale cooling facility in any year in which 100 percent of facility blowdown water is beneficially reused.*

2. *The requirement set forth in subsection A of this section does not apply to any effluent-served cooling tower at a large-scale cooling facility during the first 12 consecutive months in which more than 50 percent of the water supplied to the cooling tower is effluent. After the 12-month period expires, the person using water at the effluent-served cooling tower may apply to the director to use an alternative blowdown level from that required in subsection A of this section if compliance with the blowdown requirement would not be possible due to the presence of a limiting constituent other than silica or total hardness in the effluent supplying the tower. To apply for an alternative blowdown level to address such a limiting constituent, an industrial user shall submit a request in writing to the director that includes the following information:*

    a. *The limiting constituent other than silica or total hardness that is present in the effluent supplying the tower that results in the need to blow down a greater annual volume of water than that required under subsection A of this section.*

    b. *Documentation describing the concentration at which this limiting constituent should be blown down and the reason for the alternative blowdown level.*

    The director shall grant the request if the director determines that the presence of a limiting constituent other than silica or total hardness in the effluent supplying the cooling tower results in the need to blow down a greater annual volume of water than that required under subsection A of this section. Any alternative blowdown level granted pursuant to this paragraph shall apply only while the tower qualifies as an effluent-served cooling tower.

3. *An industrial user may apply to the director to use an alternative blowdown level from that required in subsection A of this section if compliance with the blowdown requirement would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness in recirculating water. To apply for an alternative blowdown level for such a limiting constituent, an industrial user shall submit a request in writing to the director that includes the following information:*

    a. *Historic, current, and projected water quality data for the relevant limiting constituent(s).*

b. Documentation describing the potential damage to cooling towers or associated equipment, or documentation of environmental standards that are likely to be exceeded, whichever applies.

The director shall grant the request if the director determines that compliance with the blowdown level set forth in subsection A of this section would likely result in damage to cooling towers or associated equipment or exceedence of federal, state, or local environmental discharge standards because of the accumulation of a limiting constituent other than silica or total hardness in recirculating water.

6-703. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which water use first commences, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user who uses water at a large-scale cooling facility shall include in its annual report required by A.R.S. § 45-632 the following information for all cooling towers with 250 tons or more of cooling capacity at the facility:

1. Capacity in tons of each cooling tower.

2. Number of days per month that each cooling tower was fully operational.

3. For each cooling tower that is exempt from cycles of concentration requirements or for which an alternative blowdown level has been granted, pursuant to section 6-702, subsection B, paragraph 2, the percentage of water served to the tower during the year that was effluent.

4. The quantity of water from any source, specified by source, that was used for make-up water on a monthly basis during the calendar year as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.

5. The quantity of water that was blown down on a monthly basis during the calendar year as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.

6. The average monthly concentrations of silica, total hardness or other approved limiting constituent established under section 6-702, subsection B, paragraph 2 or 3, in make-up and blowdown water for those portions of each month when cooling towers were fully operational during the calendar year, reported in mg/l or other measurement units established under section 6-702, subsection B, paragraph 2 or 3, and either:

a. Determined by direct analysis; or

b. Calculated based on average monthly electrical conductivity readings for those portions of each month when cooling towers were fully operational if the following conditions have been met: (a) correlations between electrical conductivity and silica, between electrical conductivity and total hardness, or between electrical conductivity and another approved limiting constituent established pursuant to section 6-702 subsection B, paragraph 2 or 3, have been established over a period of one year or more in make-up and blowdown water; and (b) documentation of these correlations has been provided to the director.

6.8 DAIRY OPERATIONS

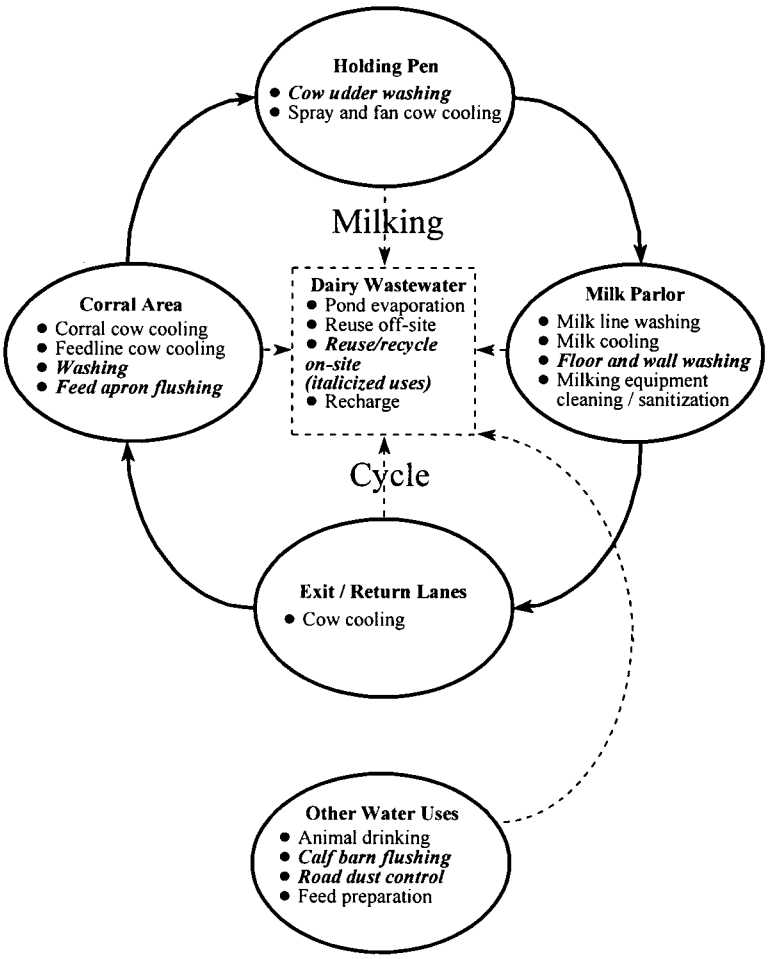
6.8.1 Introduction

The Department regulates dairy operations that annually house a monthly average of 100 or more lactating cows per day. The majority of water use at dairies occurs for animal drinking needs, udder washing, barn cleanup, and animal cooling.

6.8.2 Water Use by Dairy Operations

The dairy industry is a small industrial water use sector in the Tucson AMA. Water use at Tucson AMA dairies ranged between 45 and 73 acre-feet per year from 1987 through 1995. Two of the AMA's three dairies went out of production during the second management period. The remaining active dairy is located in the Marana area and is undergoing expansion. This dairy holds a Type 2 non-irrigation grandfathered right that allows withdrawal of up to 210 acre-feet of groundwater per year. Water use at this dairy was 73 acre-feet in 1995. Water use is projected to increase to around 200 acre-feet per year due to expansion and continue at this level through 2025. Many of Arizona's large dairies are located in the Phoenix AMA. However, due to rapid urbanization, dairies may relocate to a more rural environment such as that found in the Pinal AMA. It is not anticipated that additional dairies will be constructed in the Tucson AMA.

FIGURE 6-8
WATER USE AT A TYPICAL DAIRY OPERATION



Italized items can use reused and/or recycled water
Not all water uses shown on this chart exist at every dairy

Figure 6-8 shows how water is used at a dairy. A significant amount of water is used for the milking cycle. The first step in the milking cycle at most dairies is moving the cows into a holding pen, where the udders are washed before milking. Sprinklers, arranged in a grid pattern on the floor of the pen, are turned on to wash the udders. The cows may be cooled during udder washing to enhance milk production. The animals are then moved to the milking parlor for milking after which they are returned to the corral area through return lanes. Each time the cycle is completed, the holding pen and parlor areas are cleaned, milk lines are cleaned and sanitized, milking equipment is cleaned, and manure is removed.

There are a number of dairy management decisions that affect water use. Animal cooling to reduce heat stress and enhance milk production is an increasingly common management practice. Cooling is usually done when temperatures exceed 85 to 90 degrees Fahrenheit and may be done at various locations, including the holding pen corral, at the parlor exit, along the fenceline feeding area, or in the corral area.

During the warm season, virtually all dairies in the AMAs cool their cows during some portion of the day. Cooling practices have increased during the past decade and are expected to continue to increase in the future. Whereas at many existing dairies lactating cows are often cooled at only one or two of the possible locations, newly designed dairies incorporate cooling wherever possible.

Milking frequency is another management decision that will affect water use. Cows may be milked two, three, or even four times daily. Increasing the milking frequency per day will increase water use. Dairy managers evaluate the benefits of milking two or three times per day based upon parlor capacity, milk yield, staffing, and other economic factors. If future market demands require increasing pounds of milk production per cow, milking up to four times a day could become commonplace.

Aside from milking, water is used for drinking needs, controlling dust, and, at the majority of dairies, feed preparation. Water used for drinking needs varies depending upon whether the animal present at the facility is a lactating cow (a cow producing milk) or a non-lactating animal (calves, heifers, dry cows, bulls, and steers). A lactating cow drinks an average of 30 gallons of water per day, and a non-lactating animal drinks an average of 15 gallons per day, with some seasonal variation.

Whether non-lactating animals are housed on or off-site can significantly affect water use. Each dairy keeps lactating and mature dry cows on-site at a ratio that remains relatively constant throughout the year, with some variation due to weather and breeding. Another management decision is whether animals such as calves and heifers are housed on-site. Approximately 40 percent of Arizona dairies raise calves and heifers off-site or do not raise them at all.

Within the milking cycle, the dairy industry practices that have the most significant water conservation potential are the udder washing process, the practice of water recycling, and, to a lesser extent, cleaning and sanitization. The typical udder washing cycle consists of a one minute washing, a two minute break, followed by a three minute washing. Many dairies have invested in automatic timers to manage the udder wash system. Timers reduce the potential for excessive manual washing, provided the timer is used appropriately. Proper management is the best way to control water waste, and the use of automatic timers can result in significant water savings. Other factors affect the amount of water used for udder washing. Regular and frequent washing of the feed apron, milking parlor, and holding pen areas reduces the potential for soiled udders and thus reduces wash water needs. Periods of wet weather result in muddy corrals, requiring longer udder washing periods or increased washing of corral walkways and milking areas.

Another important water conservation practice for dairies is recycling of wastewater generated by the dairy. Wastewater may be conveyed to a lagoon where it evaporates, delivered off-site for non-dairy uses (such as irrigating certain crops), or recycled and reused at the dairy. There are many opportunities for recycling at a dairy. Milk cooling using vacuum pumps produces discharged water that can be captured and used in the udder washing cycle or for certain other washing and cleaning purposes. At some facilities, and depending upon how the recycled water is used initially, this water can be captured a second time and used again. For example, recycled water used for udder washing may be recycled again to wash corral walkways. Recycling offers the dairy manager several benefits, including: lower water costs, less wastewater to dispose of, less free-standing water, drier conditions, and cleaner cows. Recycling should be evaluated and implemented wherever feasible in new dairies. Health and sanitary requirements may prohibit the use of recycled water for certain water uses at a dairy.

At many dairies, the amount of water used for cleaning and sanitizing the holding pen, milking parlor, and milk transport lines after each milking increases during the summer months, though no increase may be warranted. Summer water use for this purpose can easily be reduced with little or no additional management or equipment costs.

6.8.3 Program Development and Issues

During the first management period, dairy operations did not have any specific conservation requirements. When the Second Management Plan was developed, the Department conducted a study to identify dairy water use patterns, processes, and associated water use to determine conservation potential for dairy operations. Several dairies were visited during the study. Experts from the University of Arizona reviewed and supplemented the study and provided significant input to the conservation requirements. Conservation requirements for the second management period established a maximum annual water allotment for dairies effective beginning in the year 2000. The maximum annual water allotment was determined using the per animal water use needs for lactating cows and non-lactating animals and could vary depending upon the number of animals at the facility. Upon application, the Department could approve an additional allocation of water for a dairy operation above its annual allotment if the dairy operation demonstrated that milking, sanitary, or cooling needs would require more water.

During the second management period, rapid changes in cooling technologies and the increased diversity in dairy size and design made it difficult for some dairies to conform to an allotment based conservation requirement like that included in the Second Management Plan. In an effort to have higher milk production efficiency, newer dairies tend to employ more cooling practices and incorporate more methods to recycle or reuse water.

The Department was informed by the Dairy Technical Advisory Committee that future dairy facilities will have to be larger and utilize these new cooling technologies in order to be economically competitive. These practices are designed to increase the milk yield per lactating cow, and will require more water than historical use indicates. The conservation program for the third management period provides dairies the opportunity to choose one of two conservation programs. Dairies may continue to be regulated under an allotment-based program identical to Second Management Plan requirements, or dairies may apply for conservation requirements that are specified "best management practices."

6.8.4 Dairy Operation Conservation Program

6.8.4.1 Allotment Based Requirements

The amount of water required by a dairy depends upon the number of cows and non-lactating animals housed at the dairy, the breed of cow, dairy management practices, and the type and water use efficiency of the technology employed. Table 6-6 summarizes daily water needs for each dairy process, assuming use of appropriate water conservation technology and practices.

The water needs listed are based on two assumptions: (1) milking is done three times per day per lactating animal and (2) cooling is done during the summer for at least a portion of the herd.

The assumptions of Table 6-6 are the basis for the annual water allotments for dairies. When calculating the total annual allotment, lactating cows are allotted 105 gallons per animal per day (GAD) while non-lactating animals are allotted 20 GAD. The allotment is calculated annually and will vary with the monthly average of lactating cows and non-lactating animals per day present at the dairy each year.

Upon application, the Department may approve an additional allocation of water for a dairy operation above its annual allotment if the dairy operation demonstrates that one or more of the following conditions exist:

- Milking is being done more than three times daily;
- Technologies that are designed to achieve industry health and sanitation objectives, such as the recommended pre-milking sanitation method, are being used;
- Animal cooling technologies designed to increase milk production are being used.

In consideration of weather variability, the Department has included a three-year averaging provision in the maximum annual water allotments in the third management period. The water use of three consecutive years can be averaged to determine if compliance with the Third Management Plan allotment has been achieved.

TABLE 6-6
WATER NEEDS AT A TYPICAL DAIRY

Operation	Water Use Allocation (gallons per day)	
	Lactating Cow	Non-Lactating Animal
Drinking needs[1]	30	15
Udder washing - based on 72 minutes/day at 8 gallons/minute; 16 cows per milking (two per group). Varies with number of milkings per day.[1]	35	0
Barn cleanup and sanitizing. Varies with number of milkings per day.[1]	20	0
Animal cooling management option, site-specific	10	0
Calf barn cleanup	0	5
Milk cooling tower (if present)	5	0
Miscellaneous	5	0
Total	105	20

[1] Assumes three milkings per day

6.8.4.2 Best Management Practices Requirements

As an alternative to the annual allotment requirement, a dairy may submit an application to the director to be regulated under the Best Management Practices Program (BMP Program). This program requires implementation of conservation and management practices to maximize efficiency in the following water use categories:

- Delivery of drinking water for dairy animals;
- Udder washing and milk parlor cleaning;
- Corral design and maintenance;
- Cleaning and sanitizing milking equipment;
- Dust control, calf housing cleaning, and feed apron flushing;
- Dairy animal cooling; and
- Dairy animal feed preparation.

Implementation of all the standard BMPs listed in Appendix 6B will have a specific measurable result. While most of the standard BMPs are applicable to all dairies, the water use activities associated with some of the standard BMPs may not exist at all dairies. If a dairy cannot implement a standard BMP, the dairy may apply to implement a substitute BMP with a specific measurable result that demonstrates a water

savings equivalent to the water savings associated with the standard BMP. If a substitute BMP is not possible, the dairy may apply for a waiver of the standard BMP. The director may grant a waiver only for the following standard BMPs: (1) BMP 2.1.2 (Udder Wash System); (2) BMP 2.2.2 (Milking Parlor Floor and Wall Washing); (3) BMP 4.1.1 (Milk Cooling and Vacuum Pump); (4) all of the standard BMPs in Water Use Category No. 5 (Dust Control, Calf Housing Cleaning, and Feed Apron Flushing); (5) all of the standard BMPs in Water Use Category No. 6 (Dairy Animal Cooling); and (6) all of the standard BMPs in Water Use Category No. 7 (Dairy Animal Feed Preparation).

Five years after a dairy is accepted for regulation under the BMP Program, the director will review the dairy's BMPs to determine if they are still appropriate. If the BMPs are no longer appropriate due to an expansion of the dairy or a change in management practices, the director will require a modification to the BMPs.

6.8.5 Non-Regulatory Efforts

Dairies stand to benefit from a conservation assistance grant that supported the construction and study of an on-site demonstration of dairy wastewater treatment through constructed wetlands in the Phoenix AMA. Wastewater from cow barns (cow washing, etc.) will be collected and solids will be removed. The wastewater will be cycled through a series of wetlands cells. The quality of water obtained from this process will be closely monitored. This treatment facility will attempt to assess the ability of constructed wetlands to produce water suitable for reuse in the dairy or for recharge.

Research is needed to further investigate the quantity of water required for various processes at a dairy operation. This should include the water use of new technologies designed to increase milk production.

6.8.6 Future Directions

Although newer dairies tend to use more water for cow cooling than older dairies by employing more cooling technologies and practices, thoughtful design will allow dairies to reuse and recycle more water than they have in the past. The latest "state of the art" dairies even collect and use rainfall. Fourth management period conservation requirements may need to be adjusted with the increased utilization of more water intensive technologies. Any adjustment to current allotments must be based on reliable data from a verifiable study. Alterations to allotments or to BMPs must be based on additional research that quantifies the water requirements associated with these new technologies or provides new information on existing technologies.

6.8.7 Industrial Conservation Requirements and Monitoring and Reporting Requirements for Dairy Operations

6-801. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes, unless the context otherwise requires, the following words and phrases used in sections 6-802 through 6-805 of this chapter shall have the following meanings:

1. *"Dairy animal" means a lactating cow or a non-lactating animal present at a dairy operation.*

2. *"Dairy operation" means a facility that houses an average of 100 or more lactating cows per day during a calendar year as calculated in section 6-802.*

3. *"Dairy wastewater" means any water that has been put to a beneficial use at the dairy operation, including water containing dairy animal wastes.*

4. *"Lactating cow" means any cow that is producing milk that is present on-site at a dairy operation and receives water through the dairy operation's watering system.*

5. *"Non-lactating animal" means a calf, heifer, mature dry cow, bull, or steer that is present on-site at a dairy operation and receives water through the dairy operation's watering system.*

6-802. Maximum Annual Water Allotment Conservation Requirements

A. Maximum Annual Water Allotment

Beginning on January 1, 2002 or upon commencement of water use, whichever is later, and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, an industrial user shall not withdraw, divert or receive water for use at a dairy operation during a calendar year in a total amount that exceeds the dairy operation's maximum annual water allotment for the year as calculated in subsection B below, unless the industrial user applies for and is accepted into the Best Management Practices Program described in section 6-804.

B. Calculation of Maximum Annual Water Allotment

A dairy operation's maximum annual water allotment for a calendar year shall be determined as follows:

1. *Calculate the average daily number of lactating cows and non-lactating animals that are present during the calendar year. The average daily number of lactating cows and non-lactating animals present during the calendar year shall be calculated as follows:*

    a. *Determine the total number of lactating cows and non-lactating animals present at the dairy operation on the last day of each month during the calendar year.*

    b. *For each category of animal, add together the total number of such animals present at the dairy operation on the last day of each month during the year in question and*

then divide the result by 12. The quotient is the average daily number of lactating cows and non-lactating animals present during the calendar year.

2. *Calculate the dairy operation's maximum annual water allotment for the calendar year as follows:*

   a. *Multiply the average daily number of lactating cows present during the calendar year by 105 gallons per animal per day (GAD) and then convert to acre-feet per year as follows:*

$$C_L \times \frac{105\ GAD}{325{,}851\ g/af} \times d/yr = \text{Maximum annual water allotment for lactating cows (acre-feet per year)}$$

   Where: C_L = *Average daily number of lactating cows*
   GAD = *Gallons per animal per day*
   g/af = *Gallons per acre-foot*
   d/yr = *Days in the year*

   The result is the dairy operation's maximum annual water allotment for lactating cows for the calendar year.

   b. *Multiply the average daily number of non-lactating animals present during the calendar year by 20 gallons per animal per day (GAD) and then convert to acre-feet per year as follows:*

$$A_N \times \frac{20\ GAD}{325{,}851\ g/af} \times d/yr = \text{Maximum annual water allotment for non-lactating animals (acre-feet per year)}$$

   Where: A_N = *Average daily number of non-lactating animals*
   GAD = *Gallons per animal per day*
   g/af = *Gallons per acre-foot*
   d/yr = *Days per year*

   The result is the dairy operation's maximum annual water allotment for non-lactating animals for the calendar year.

   c. *Add the dairy operation's maximum annual water allotment for non-lactating animals for the calendar year as calculated in subparagraph b of this paragraph and the dairy operation's maximum annual water allotment for lactating cows for the calendar year as calculated in subparagraph a of this paragraph. The sum is the maximum annual water allotment for the dairy operation for the calendar year, except as provided in subparagraph d of this paragraph.*

   d. *Upon application, the director may approve an additional allocation of water for the dairy operation consistent with industry health and sanitation objectives if the dairy operation requires more than its maximum annual water allotment because of one or more of the following:*

1) *milkings per lactating cow occur more than three times daily,*

2) *technologies are used to achieve industry health and sanitation objectives that require additional water use, or*

3) *technologies are designed and/or implemented for cooling lactating cows and non-lactating animals that increase milk production.*

3. *Nothing in this section shall be construed to authorize a person to use more water from any source than the person is entitled to use pursuant to a groundwater or appropriable water right or permit held by the person. Nor shall this section be construed to authorize a person to use water from any source in a manner that violates Chapter 1 or Chapter 2 of Title 45, Arizona Revised Statutes.*

6-803. Compliance with Maximum Annual Water Allotment

An industrial user who uses water at a dairy operation is in compliance for a calendar year with the dairy operation's maximum annual water allotment if the director determines that either of the following applies:

1. *The volume of water withdrawn, diverted, or received during the calendar year for use at the dairy operation, less the volume of dairy wastewater delivered from the dairy operation to the holder of a grandfathered groundwater right for a beneficial use, is equal to or less than the dairy operation's maximum annual water allotment for the calendar year; or*

2. *The three-year average volume of water withdrawn, diverted, or received for use at the dairy operation during that calendar year and the preceding two calendar years is equal to or less than the dairy operation's three-year average maximum annual water allotment for that calendar year and the preceding two calendar years. In calculating the three-year average volume of water withdrawn, diverted or received for use at the dairy operation, the volume of dairy wastewater delivered from the dairy operation to the holder of a grandfathered right for a beneficial use shall not be counted.*

6-804. Best Management Practices Program Conservation Requirements

A. Criteria for Approval of Application

An industrial user who uses water at a dairy operation may apply for regulation under the Best Management Practices Program (BMP Program) by submitting an application on a form provided by the director. The director shall approve a complete and correct application for regulation under the BMP Program if the director determines that the applicant will implement all of the standard best management practices (BMPs) described in Appendix 6B, unless the director approves a substitution of a standard BMP under subsection D of this section or a waiver of a standard BMP under subsection E of this section. If the director approves a substitution of a standard BMP, the director shall approve the application if the director determines that the applicant will implement the substitute BMP or BMPs in addition to any remaining standard BMPs.

B. Exemption from Maximum Annual Water Allotment Conservation Requirements

An industrial user accepted for regulation under the BMP Program is exempt from the maximum annual water allotment conservation requirements set forth in section 6-802 beginning on January 1 of the first calendar year after the industrial user's application for the BMP Program is approved, unless the director approves an earlier date.

C. Compliance with Best Management Practices Program

Beginning on a date established by the director and continuing thereafter until the first compliance date for any substitute conservation requirement established in the Fourth Management Plan, an industrial user accepted for regulation under the BMP Program shall comply with all standard BMPs listed in Appendix 6B, unless the director approves a substitution of a standard BMP under subsection D of this section, or a waiver of a standard BMP under subsection E of this section. If the director approves a substitution of a standard BMP the industrial user shall comply with the substitute BMP or BMPs in addition to any remaining standard BMPs. The standard BMPs listed in Appendix 6B are broken into the following seven categories: (1) delivery of drinking water for dairy animals; (2) udder washing and milking parlor cleaning; (3) corral design and maintenance; (4) cleaning and sanitizing milking equipment; (5) dust control, calf housing cleaning, and feed apron flushing; (6) dairy animal cooling; and (7) dairy animal feed preparation.

D. Substitution of Best Management Practices

1. *The director may allow an industrial user applying for the BMP Program to replace a standard BMP listed in Appendix 6B with a substitute BMP if the director determines that the standard BMP cannot be achieved and that implementation of the substitute BMP will result in water use efficiency equivalent to that of the standard BMP. To apply for a substitution of a standard BMP, the industrial user shall include in its application for the BMP Program an explanation of why the standard BMP is not achievable and a description of how the substitute BMP will result in water use efficiency equivalent to that of the standard BMP.*

2. *An industrial user regulated under the BMP Program may apply to the director for a substitution of an existing BMP that is no longer appropriate for the industrial user's dairy operation. The director may allow the industrial user to replace the existing BMP with a substitute BMP if the director determines that the substitute BMP will result in water use efficiency equivalent to that of the existing BMP.*

E. Waiver of Best Management Practices

1. *The director may waive a standard BMP listed in paragraph 3 of this subsection if the director determines that the standard BMP cannot be achieved and that no substitute BMP is appropriate. To apply for a waiver of a standard BMP listed in paragraph 3, the industrial user shall include in its application for the BMP Program an explanation of why the standard BMP is not achievable and why no substitute BMP is appropriate.*

2. *An industrial user regulated under the BMP Program may apply to the director for a waiver of an existing BMP listed in paragraph 3 of this subsection if the BMP is no longer appropriate for the industrial user's dairy operation. The director may waive the existing BMP if the director determines that the existing BMP is no longer appropriate for the industrial user's dairy operation and the that no substitute BMP is appropriate.*

3. *Only the following standard BMPs may be waived by the director under this subsection: (1) BMP 2.1.2 (Udder Wash System); (2) BMP 2.2.2 (Milking Parlor Floor and Wall Washing); (3) BMP 4.1.1 (Milk Cooling and Vacuum Pump); (4) all of the standard BMPs in Water Use Category No. 5 (Dust Control, Calf Housing Cleaning, and Feed Apron Flushing); (5) all of the standard BMPs in Water Use Category No. 6 (Dairy Animal Cooling); and (6) all of the standard BMPs in Water Use Category No. 7 (Dairy Animal Feed Preparation).*

F. Five Year Review of Best Management Practices

Five years after an industrial user is accepted for regulation under the BMP Program, the director shall review the industrial user's BMPs to determine whether any changes in the BMPs are warranted. If the director determines that any of the existing BMPs are no longer appropriate due to an expansion of the dairy operation or a change in management practices at the operation, the director shall notify the industrial user in writing of that determination and the director and the industrial user shall make a good faith effort to stipulate to a modification of the BMPs so that they are appropriate for the expanded operation or the change in management practices.

If the director and the industrial user are unable to stipulate to a modification to the BMPs within 180 days after the director notifies the industrial user of the determination that one or more of the existing BMPs are no longer appropriate or such longer time as the director may agree to, the industrial user shall no longer be regulated under the BMP Program but shall thereafter be required to comply with the maximum annual water allotment conservation requirements set forth in section 6-802.

If the director and the industrial user stipulate to a modification of the BMPs, the industrial user shall comply with the modified BMPs by a date agreed upon by the director and the industrial user and shall continue complying with the modified BMPs until the first compliance date for any substitute conservation requirement in the Fourth Management Plan.

G. Change in Ownership of Dairy Operation

1. *If an industrial user regulated under the BMP Program sells or conveys the dairy operation to which the BMPs apply, the new owner of the dairy operation shall continue to be regulated under the BMP Program until January 1 of the first calendar year after acquiring ownership of the dairy operation. Except as provided in paragraph 2 of this section, beginning on January 1 of the first calendar year after acquiring ownership of the dairy operation, the new owner shall comply with the maximum annual water allotment conservation requirements set forth in section 6-802. The new owner may at any time apply for regulation under the BMP Program.*

2. *If the new owner submits a complete and correct application for regulation under the BMP Program prior to January 1 of the first calendar year after acquiring ownership the of the dairy operation, the new owner shall continue to be regulated under the BMP Program until the director makes a determination on the application. If the director denies the application, the new owner shall be required to comply with the maximum annual water allotment conservation requirements set forth in section 6-802 immediately upon notification of the denial or January 1 of the first calendar year after acquiring ownership of the dairy, whichever is later. If the director approves the application, the new owner shall continue to be regulated under the BMP Program until the first*

compliance date for any substitute conservation requirement in the Fourth Management Plan.

6-805. Monitoring and Reporting Requirements

For the calendar year 2002 or the calendar year in which water use is commenced at the dairy operation, whichever occurs later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirements in the Fourth Management Plan, an industrial user who uses water at a dairy operation shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water from any source, including effluent, withdrawn, diverted, or received during the calendar year for use by the dairy operation, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

2. *The total quantity of water delivered during the calendar year to any uses other than the dairy operation from the well or wells that serve the dairy operation, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R12-15-901, et seq.*

3. *The total quantity of dairy wastewater delivered to grandfathered rights other than the dairy operation, as measured with a measuring device in accordance with the Department's measuring device rules, A.A.C. R-12-15-901, et seq.*

4. *The total number of lactating cows and non-lactating animals that were present on-site at the dairy operation on the last day of each month during the calendar year.*

5. *If the dairy operation is regulated under the BMP Program, any documentation as required by the director that demonstrates compliance with the program.*

6.9 NEW LARGE LANDSCAPE USERS

6.9.1 Introduction

New large landscape users are industrial users with substantial water-intensive landscaped area that was planted after January 1, 1990. The conservation program differentiates between two types of new large landscape users: non-residential facilities that are hotels or motels and non-residential facilities that are not hotels or motels. If the facility is not a hotel or motel, conservation requirements apply to landscapable areas in excess of 10,000 square feet. If the facility is a hotel or motel, requirements apply to landscapable areas in excess of 20,000 square feet. If a facility has 10 or more acres of water-intensive landscaped area it is defined as a turf-related facility and is subject to specific conservation requirements discussed in section 6.3 of this chapter.

6.9.2 Water Use by New Large Landscape Users

Water use associated with landscaping is directly related to the size of the landscaped area, the types of vegetation, and the efficiency of the irrigation method used. Although low water use residential landscaping is common in Tucson, significant water use may be associated with the landscaping of industrial parks, and large commercial and institutional facilities. A 9-acre hotel landscape could use more than 40 acre-feet per year if it was planted entirely with water-intensive plants. This is enough water to supply about 130 households per year. By restricting lush plantings and water features to those areas that may be used for recreation or near areas that receive the most visitation, considerable water savings may be realized. Under the Third Management Plan requirements, this same facility would use about 10 acre-feet per year to meet its landscaping needs while still maintaining an esthetically pleasing and lush landscape.

Both the City of Tucson and Pima County have ordinances that place some restrictions on new non-residential landscaping in these jurisdictions. While these ordinances have multiple objectives, they also have provisions that address water conservation. Some of these provisions include the placement of plants based on their water needs, planting of low water use plants in certain areas and preservation of native vegetation.

No new large landscape users served by their own wells, rather than by a municipal water provider, were identified during the second management period. While many large resorts and commercial facilities are constructed within water provider service areas, the potential exists for new facilities to be served by their own wells, particularly those that are associated with development on retired farmland in outlying areas of the AMA. It is difficult to predict the extent of growth possible in this subsector, but the potential for future facility construction and for corresponding significant water use does exist as the Tucson area grows.

6.9.3 Program Development and Issues

Consultant studies done for the Second Management Plan indicated that significant reductions in landscape water use can be achieved using the following techniques:

- Improving water application efficiency through proper irrigation scheduling, use of more sophisticated control systems, conversion to drip irrigation, and grouping plants with similar water needs.
- Reducing the size and perimeter of turfed areas and limiting the placement of turfed areas to functional use areas and areas of high visual impact.
- Using drought-resistant plant species adapted to the desert.
- Using proper planting, fertilization, and maintenance techniques.

- Grading sites to direct rainfall into planted areas.
- Avoiding the use of water-intensive plants within rights-of-way thus emphasizing the community's commitment to low water use designs.

The findings from these studies still apply for the third management period. Attractive landscapes can be maintained solely with rainfall. However, a lush, colorful, low water use landscape, watered by a permanent drip irrigation system, is considered more desirable for commercial and industrial landscape applications. This type of landscape results in water savings of 50 to 75 percent of the amount used by a well-maintained turf (water-intensive) landscape.

The distinction in the program between hotel or motel landscapes and landscapes that are associated with facilities that are not hotels or motels is intended to address the contention by the lodging industry that for certain hotel and motel developments there is an economic benefit from planting high water using landscape plant material, thus economically justifying a larger water-intensive area.

6.9.4 New Large Landscape User Conservation Program

The new large landscape user program for the Third Management Plan is similar to that in the Second Management Plan. In addition to the requirements that apply to all industrial users, new large landscape users must limit the percentage of water-intensive landscaped area above a specified square footage. The facility must limit its water-intensive landscaped area to the greater of the following: 1) 10,000 square feet (20,000 square feet for hotels and motels) plus twenty percent of the area in excess of 10,000 square feet (20,000 square feet for hotels and motels); and 2) the total surface area of all bodies of water within the facility that qualify as water intensive landscaped area.

Water-intensive landscaping includes not only high water using plants such as turf, but also bodies of water such as ponds. However, it does not include any area of land watered exclusively with direct use effluent or effluent recovered within the area of impact, bodies of water used primarily for swimming, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact, and bodies of water allowed under an interim water use permit pursuant to the Lakes Bill if the body of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires. If 100 percent wastewater is used to water the landscape, the requirements do not apply. For example, if there is sufficient cooling tower blowdown water and greywater available from the operations of a hotel, this wastewater could be used to water any amount of water-intensive landscaped area up to 10 acres. Once a water-intensive landscaped area equals or exceeds 10 acres in size, it is defined as a turf-related facility and is subject to regulation under that program.

6.9.5 Industrial Conservation Requirements and Monitoring and Reporting Requirements for New Large Landscape Users

6-901. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes and section 6-201 of this chapter, unless the context otherwise requires, the following words and phrases used in sections 6-902 and 6-903 of this chapter shall have the following meanings:

1. *"Direct use effluent" means effluent transported directly from a facility regulated pursuant to Title 49, Chapter 2, Arizona Revised Statutes, to an end user. Direct use effluent does not include effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes.*

2. *"Effluent recovered within the area of impact" means effluent that has been stored pursuant to Title 45, Chapter 3.1, Arizona Revised Statutes, and recovered within the stored effluent's area of impact. For purposes of this definition, "area of impact" has the same meaning as prescribed by A.R.S. § 45-802.01.*

3. *"Landscapable area" means the entire area of a lot less any areas covered by structures, parking lots, roads, or any other area not physically capable of being landscaped.*

4. *"New large landscape user" means a non-residential facility that has a water-intensive landscaped area in excess of 10,000 square feet and that has landscaping planted and maintained after January 1, 1990 or bodies of water, other than bodies of water used primarily for swimming purposes, filled and maintained after January 1, 1990, or both. Turf-related facilities as defined in section 6-301 of this chapter are excluded from this definition.*

5. *"Water-intensive landscaped area" means, for the calendar year in question, all of the following areas within a non-residential facility:*

    a. *Any area of land that is planted primarily with plants not listed in Appendix 5B, Low Water Use/Drought Tolerant Plant List, or any modifications to the list, and watered with a permanent water application system, except any area of land that is watered exclusively with direct use effluent or effluent recovered within the area of impact.*

    b. *The total water surface area of all bodies of water within the facility, except bodies of water used primarily for swimming purposes, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact, and bodies of water allowed under an interim water use permit pursuant to A.R.S. § 45-133 if the bodies of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires.*

6-902. Conservation Requirements

A. Conservation Requirements for New Large Landscape Users that are not Hotels or Motels

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, the water-

intensive landscaped area within a new large landscape user that is not a hotel or motel shall not exceed the greater of the following: 1) an area calculated by adding 10,000 square feet plus 20 percent of the facility's landscapable area in excess of 10,000 square feet; and 2) the total water surface area of all bodies of water within the facility that are allowed under A.R.S. § 45-131, et seq., and that qualify as water-intensive landscaped area.

B. Conservation Requirements for New Large Landscape Users that are Hotels or Motels

Beginning on January 1, 2002 and continuing thereafter until the first compliance date for any substitute conservation requirement in the Fourth Management Plan, the water-intensive landscaped area within a new large landscape user that is a hotel or motel shall not exceed the greater of the following: 1) an area calculated by adding 20,000 square feet plus 20 percent of the facility's landscapable area in excess of 20,000 square feet; and 2) the total water surface area of all bodies of water within the facility that are allowed under A.R.S. § 45-131, et seq., and that qualify as water-intensive landscaped area.

C. Waiver of Conservation Requirements for the Use of 100 Percent Wastewater

The conservation requirements set forth in subsections A and B of this section shall not apply to a new large landscape user in any year in which all of the water used for landscaping purposes within the facility is wastewater.

6-903. Monitoring and Reporting Requirements

For calendar year 2002 or the calendar year in which the facility first begins to use water, whichever is later, and for each calendar year thereafter until the first compliance date for any substitute monitoring and reporting requirement in the Fourth Management Plan, an industrial user that applies water to a new large landscape user shall include the following information in its annual report required by A.R.S. § 45-632:

1. *The total quantity of water from any source, including effluent, withdrawn, diverted, or received for use on the facility during the calendar year for landscape watering purposes, including bodies of water filled or refilled during the calendar year, as measured with a measuring device in accordance with the Department's measuring device rules. A.A.C. R12-15-901, et seq.*

2. *The total amount of landscapable area within the facility.*

3. *The total amount of water-intensive landscaped area at the facility broken down into the area planted primarily with plants not on the Low Water Use/Drought Tolerant Plant List, or any modifications to the list (except any area watered exclusively with direct use effluent or effluent recovered within the area of impact) and the surface area of all bodies of water (except bodies of water used primarily for swimming purposes, bodies of water filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact, and bodies of water allowed under an interim water use permit if the bodies of water will be filled and refilled exclusively with direct use effluent or effluent recovered within the area of impact after the permit expires).*

6.10 NEW LARGE INDUSTRIAL USERS

6.10.1 Introduction

New large industrial users are industrial users that use in excess of 100 acre-feet of water per year and commence use after January 1, 2000. In the Second Management Plan, new large industrial users were defined as industrial users that use in excess of 100 acre-feet per year and commenced use after January 1, 1990. As of 1999, all of the new large industrial users identified in the Tucson AMA were industrial users subject to specific conservation requirements discussed elsewhere in this chapter (e.g., metal mines, turf-related facilities, etc.).

6.10.2 Water Use by New Large Industrial Users

In 1995, there were seven industrial facilities in the Tucson AMA, other than metal mines, sand and gravel facilities, turf-related facilities, electric power plants, and dairy operations, that individually used more than 100 acre-feet of water during the year. The combined water use of these facilities during 1995 was approximately 2,800 acre-feet. However, none of these facilities qualified as a new industrial user under the Second Management Plan because each commenced water use prior to January 1, 1990. These facilities use groundwater pursuant to 14 Type 2 non-irrigation grandfathered rights and permits with allotments totaling 12,616 acre-feet. The facilities include cement plants, electronics industries, hospitals, and others. There are an additional 36 rights and permits with allotments of over 100 acre-feet per year, these rights are either being used to withdraw less than 100 acre-feet per year or are not being used at all. The allotments for these thirty six rights and permits total over 71,000 acre-feet, most of which is held by the City of Tucson and others for municipal uses. Although some of this large volume could potentially be used to serve new large industrial users, growth potential is difficult to predict. New large commercial or manufacturing facilities are often constructed within water company service areas and are customers of the water provider.

6.10.3 Program Development and Issues

There were no requirements for new industrial users in the First Management Plan. In addition to the conservation requirements for all industrial users, the Second Management Plan contains a specific conservation requirement for new industrial users that use over 100 acre-feet of water per year. In the Second Management Plan, new industrial users were required to prepare and submit a water conservation plan addressing the water conservation opportunities at the facility. The user was required to develop a plan that:

- describes the level of water conservation that can be achieved,
- identifies the water uses and conservation opportunities within the facility,
- describes an ongoing water conservation education program for employees, and
- includes an implementation schedule.

The Department has determined that submitting a conservation plan is a reasonable requirement to continue for the Third Management Plan considering the large volume of unused allotments that could be used for new large industrial uses and the corresponding opportunity to design water conservation into new or expanding facilities. When facilities expand, even after operation has commenced, there are additional water conservation opportunities associated with being able to "build in" water conserving designs. This is typically more economical and more feasible than retrofitting a facility that is not expanding.

6.10.4 New Large Industrial User Conservation Program

The new large industrial user program for the Third Management Plan is identical to that of the Second Management Plan. In addition to the requirements that apply to All Industrial Users, new large industrial users must prepare and submit a water conservation plan to the director. However, if the user is required to submit a conservation plan under another section of this chapter, it can combine the plans and submit one plan.

The water conservation plan must show how much water conservation can be achieved at the facility. It must identify how water is used at the facility and what can be done to conserve in major water use areas. The plan must also detail an employee water conservation education program at the facility and describe when conservation measures will be implemented.

6.10.5 Industrial Conservation Requirements and Monitoring and Reporting Requirements for New Large Industrial Users

6-1001. Definitions

In addition to the definitions set forth in Chapters 1 and 2 of Title 45 of the Arizona Revised Statutes and section 6-201 of this chapter, "new large industrial user" means an industrial user that begins using more than 100 acre-feet of water per year for industrial purposes after January 1, 2000.

6-1002. Conservation Requirements

A. *Not later than January 1, 2002 or within 180 days after the end of the first calendar year in which the facility first uses more than 100 acre-feet of water for industrial purposes, whichever is later, a new large industrial user shall submit to the director a plan to improve the efficiency of water use by the facility. The plan shall:*

1. *Specify the level of water conservation that can be achieved assuming the use of the latest commercially available technology consistent with reasonable economic return;*

2. *Identify water uses and conservation opportunities within the facility, addressing water used for the following categories as appropriate: landscaping; space cooling; process-related water use, including recycling; and sanitary and kitchen uses;*

3. *Describe an ongoing water conservation education program for employees; and*

4. *Include an implementation schedule.*

B. *If a person required to submit a plan under subsection A of this section is required to submit a conservation plan under another section of this chapter, the person may combine the plans into a single conservation plan.*

REFERENCES

Brown, P., Gilbert, J., and D. Kopec, 1996. *Final Report to the Arizona Department of Water Resources, Turfgrass Irrigation Scheduling Using Weather Based Estimates of Evapotranspiration for High and Low Traffic Turfs*. Contract No. CA94TU103-00, May 31, 1996.

APPENDIX 6A
TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA

Facility Name	Water Source	Water Supply	Right Number
CEMETERIES			
East Lawn Cemetery	City of Tucson	Effluent	56-000001
Evergreen Cemetery	Type 2 GFR	Groundwater	58-109101
Holy Hope Cemetery	Type 2 GFR	Groundwater	58-108519
South Lawn Cemetery	Type 2 GFR	Groundwater	58-109112
GOLF COURSES			
Arthur Pack GC	Pima County	Effluent	NA
Cliff Valley GC	Type 2 GFR	Groundwater	58-100274
CC of Green Valley	Type 2 GFR	Groundwater	58-101735
Dell Urich GC	City of Tucson	Effluent	56-000001
Desert Hills GC	Green Valley WC	Groundwater	56-000302
Dorado CC	Type 2 GFR	Groundwater	58-108946
El Conquistador CC	Town of Oro Valley	Groundwater	56-000368
El Conquistador Resort GC	Town of Oro Valley	Groundwater	56-000368
El Rio GC	City of Tucson	Effluent	56-000001
Forty-Niner GC	Forty-Niner WC	Groundwater	56-000088
Fred Enke GC	City of Tucson	Effluent	56-000001
The Gallery at Dove Mountain	City of Tucson	Effluent	56-000001
Gen. Wm Blanchard GC	Davis-Monthan AFB	Groundwater	56-000058
The Golf Club at Vistoso	Town of Oro Valley	Groundwater	56-000368
Haven GC	Type 2 GFR	Groundwater	58-104567
Heritage Highlands GC	City of Tucson	Effluent	56-000001
La Paloma GC	City of Tucson	Effluent	56-000001
The Links at Continental Ranch	Type 1 / Type 2 GFRs	Groundwater	58-160014
Morry Canoa Hills GC	Green Valley WC	Groundwater	56-000302
Mountain View GC	Lago del Oro WC	Groundwater	56-000245
Oro Valley CC	Type 2 GFR	Groundwater	58-101530
Quail Creek CC	Type 1 GFR	Groundwater	58-105292
Randolph GC	City of Tucson	Effluent	56-000001
Raven GC at Sabino Springs	City of Tucson	Effluent	56-000001
Rolling Hills CC	Type 2 GFR	Groundwater	58-112457
SaddleBrooke GC	Lago del Oro WC	Groundwater & Effluent	56-000245
San Ignacio GC	Green Valley WC	Groundwater	56-000302
Santa Rita CC	Type 2 GFR	Groundwater	58-107119
Silverbell GC	City of Tucson	Effluent	56-000001
Skyline CC	City of Tucson	Effluent	56-000001
StarrPass GC	City of Tucson	Effluent	56-000001
Sun City Vistoso GC	Town of Oro Valley	Groundwater	56-000368
Torres Blancas GC	Type 1 / Type 2 GFRs	Groundwater	58-101963
Tucson CC	Type 2 GFR / City of Tucson	Groundwater & Effluent	58-106007
Tucson Estates GC	City of Tucson	Groundwater	56-000001
Tucson National GC	Type 2 GFR	Groundwater	58-102307
Ventana Canyon GC	City of Tucson	Effluent	56-000001

APPENDIX 6A
TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA

Facility Name	Water Source	Water Supply	Right Number
PARKS			
Dennis Weaver Park	Metropolitan DWID	Groundwater	56-000349
Christopher Columbus Pk	City of Tucson	Groundwater	56-000001
Fort Lowell Park	City of Tucson	Effluent	56-000001
Golf Links Sports Complex	City of Tucson	Effluent	56-000001
Himmel Park	City of Tucson	Effluent	56-000001
Jack Conrad's Golf Practice Range	Type 2 GFR	Groundwater	58-113289
Jacobs Park	City of Tucson	Effluent	56-000001
Jesse Owens Park	City of Tucson	Effluent	56-000001
Kennedy Park	City of Tucson	Groundwater	56-000001
Lakeside Park	City of Tucson	Effluent	56-000001
The Club at La Mariposa	Type 1 GFR	Groundwater	58-109720
Lincoln Park	City of Tucson	Effluent	56-000001
Mansfield Park	City of Tucson	Groundwater	56-000001
Manzanita Park	City of Tucson	Groundwater	56-000001
Marana Park	Town of Marana	Groundwater	56-000107
McCormick Park	City of Tucson	Effluent	56-000001
Mission Park	City of Tucson	Groundwater	56-000001
Joaquin Murrieta Park	City of Tucson	Effluent	56-000001
Palo Verde Park	City of Tucson	Effluent	56-000001
Pima County Fairgrounds	Type 2 GFR	Groundwater	58-100381
The Practice Tee	City of Tucson	Groundwater	56-000001
Reid Park	City of Tucson	Effluent	56-000001
Rodeo Park	City of Tucson	Groundwater	56-000001
Sam Lena Park	City of Tucson	Groundwater	56-000001
Santa Rita Park	City of Tucson	Groundwater	56-000001
Sunnyside Park	City of Tucson	Groundwater	56-000001
Udall Park	City of Tucson	Effluent	56-000001
SCHOOLS			
Amphitheater HS	Type 2 GFR	Groundwater	58-112278
Amphitheater JHS	Type 2 GFR	Groundwater	58-112278
Apollo Middle School	City of Tucson	Groundwater	56-000001
Canyon del Oro HS	Type 2 GFR	Groundwater	58-112278
Catalina HS	City of Tucson	Groundwater	56-000001
Catalina Foothills HS	City of Tucson	Groundwater	56-000001
Chaparral Middle School	City of Tucson	Groundwater	56-000001
Cherry Field	City of Tucson	Groundwater	56-000001
Cholla HS	City of Tucson	Groundwater	56-000001
Coronado School	Type 2 GFR	Groundwater	58-112278
Cross Middle School	Type 2 GFR	Groundwater	58-112278
Desert View HS	City of Tucson	Groundwater	56-000001
Doolen Middle School	City of Tucson	Groundwater	56-000001
Duffy/Gump Schools	City of Tucson	Groundwater	56-000001
Esperero Middle School	City of Tucson	Groundwater	56-000001
Fickett Middle School	City of Tucson	Groundwater	56-000001
Flowing Wells JHS	Flowing Wells ID	Groundwater	56-000084

APPENDIX 6A
TURF-RELATED FACILITIES
TUCSON ACTIVE MANAGEMENT AREA

Facility Name	Water Source	Water Supply	Right Number
Flowing Wells HS	Flowing Wells ID	Groundwater	56-000084
Gridley Middle School	City of Tucson	Groundwater	56-000001
Magee Middle School	City of Tucson	Groundwater	56-000001
Marana JHS	Type 2 GFR	Groundwater	58-111064
Marana HS	Type 2 GFR	Groundwater	58-111066
Naylor Middle School	City of Tucson	Groundwater	56-000001
Orange Grove Middle School	City of Tucson	Groundwater	56-000001
Palo Verde HS	City of Tucson	Groundwater	56-000001
Pistor Middle School	City of Tucson	Groundwater	56-000001
Pueblo HS	City of Tucson	Groundwater	56-000001
Rincon HS	City of Tucson	Groundwater	56-000001
Sabino HS	City of Tucson	Groundwater	56-000001
Sahuarita School	Withdrawal Permit	Groundwater	59-509091
Sahuaro HS	City of Tucson	Groundwater	56-000001
Santa Rita HS	City of Tucson	Groundwater	56-000001
Secrist Middle School	City of Tucson	Groundwater	56-000001
Sierra Middle School	City of Tucson	Groundwater	56-000001
Townsend Middle School	City of Tucson	Groundwater	56-000001
Tucson HS	City of Tucson	Groundwater	56-000001
Utterback Middle School	City of Tucson	Groundwater	56-000001
Vail Middle School	City of Tucson	Groundwater	56-000001

APPENDIX 6B
DAIRY OPERATION BEST MANAGEMENT PRACTICES PROGRAM
STANDARD BEST MANAGEMENT PRACTICES

WATER USE CATEGORY 1. DELIVERY OF DRINKING WATER FOR DAIRY ANIMALS **Description:** The level of milk production, season of year and type of dairy animal housing has a significant effect on the water intake of a dairy animal. The drinking water needs of a lactating cow will vary from 25 to 45 gallons per day. As milk production per cow per day increases, drinking water intake will also increase. Conservation of dairy animal drinking water could best be accomplished by preventing and promptly repairing leaks in the drinking water system.	
BMP 1.1	Install and maintain valves and floats throughout the drinking water system to allow for the isolation of leaks in lines and tanks. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all valves and floats. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the location of the valves or floats.
BMP 1.2	Inspect the drinking water system for leaks daily to ensure that leaks are promptly identified and repaired to prevent water loss. If a leak occurs, stop water flow by isolating the area of the leak and/or repair the leak within 72 hours.
WATER USE CATEGORY 2. UDDER WASHING AND MILKING PARLOR CLEANING **Description:** Udder washing and milking parlor cleaning is the single largest water use at a dairy operation. Floor and wall wash and sanitation of the milking area is necessary for producing a safe product. These systems can be either manual or semi-automatic. The amount of water used also depends on weather conditions. Udder washing and milking parlor cleaning offer the greatest conservation potential at a dairy through management of the system.	
2.1 UDDER WASH SYSTEM	
BMP 2.1.1	Install and operate the udder washing system with automatic timers. When udder washing, use a maximum of one minute of water for the soak cycle followed by a minimum of two minutes off and a maximum of three minutes of water for the wash cycle followed by one minute off. Repeat with a second wash cycle if needed.
BMP 2.1.2	Install a grid no larger than six feet by five feet between sprinkler heads on wash pens installed or renovated after January 1, 2002. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all sprinkler heads and the dimensions of the wash pens. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the location of the sprinkler heads or to the dimensions of the wash pens.

BMP 2.1.3	Install lock-out devices so that the wash system can be used only once per group of cows unless exceptional conditions require an override of the lock-out device. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all lock-out devices. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the location of the lock-out devices.
BMP 2.1.4	Establish and implement an inspection schedule to properly maintain and replace spray heads and timing devices. Inspect all spray heads and timing devices daily to ensure that they are operating correctly. If a device is found to be malfunctioning, repair or replace the device within 72 hours.
2.2	**MILKING PARLOR FLOOR AND WALL WASHING**
BMP 2.2.1	Equip all parlor hoses with shut-off valves. Inspect all hoses and valves daily. If a leak occurs, stop water flow by isolating the area of the leak and/or repair the leak within 72 hours.
BMP 2.2.2	If a semi-automatic floor flush system is used, it must be equipped with a timing device to limit the duration of cleaning and be designed to use no more water than necessary unless the water used is water recycled within the dairy operation. The Annual Report required by A.R.S. § 45-632 shall include a description of the flush system that includes the flush schedule and the amount of water used for each flush. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the timing device.
WATER USE CATEGORY 3. CORRAL DESIGN AND MAINTENANCE **Description:** Proper corral design and maintenance will reduce water use in the cow wash pen prior to milking by reducing the amount of wash time necessary to clean the cow. Sloping and maintaining the corral in a dry condition keeps the cow in a cleaner condition.	
BMP 3.1	Slope corrals to prevent standing water and to promote drainage to the wastewater system. The Annual Report required by A.R.S. § 45-632 shall include a dairy facility map that shows the corral design and the direction of slope. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to corral design.

BMP 3.2	Scrape, harrow or drag corrals to eliminate holes and maintain corrals in a dry condition. The Annual Report required by A.R.S. § 45-632 shall include a description of corral maintenance for wet and dry conditions and a maintenance schedule. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in corral maintenance.
WATER USE CATEGORY 4. CLEANING AND SANITIZING MILKING EQUIPMENT **Description:** Cleaning and sanitizing milking equipment is necessary to provide a safe dairy product. Water is also used in pre-coolers and vacuum pumps during the milking operation. Water used for this purpose is usually between 5-10 percent of the total water use at the dairy operation. This water can be recycled for other uses at the dairy.	
4.1 MILK COOLING AND VACUUM PUMP	
BMP 4.1.1	If the milk cooling and vacuum pump system is water-cooled and is not a closed system, reuse water from the system to wash cow udders or pens, or for any other uses, consistent with state and federal sanitary codes. The Annual Report required by A.R.S. § 45-632 shall include a description and diagram of how water is reused from the milk cooling and vacuum pump system. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in how water is reused from the milk cooling and vacuum pump system.
4.2 MILK LINE WASHING	
BMP 4.2.1	Install and operate the milk line washing system with an automatic or semi-automatic timing device. The Annual Report required by A.R.S. § 45-632 shall include a description of how the milk line washing system operates. The description shall include the number of cycles per washing and the amount of water used per washing. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the number of cycles per washing and the amount of water used per washing.
4.3 BACK-FLUSH SYSTEMS	
BMP 4.3.1	Maintain and service all back-flush systems in accordance with the manufacturer's design specifications and maintenance schedule. The Annual Report required by A.R.S. § 45-632 shall include the manufacturer's design specifications and a maintenance schedule. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the back flush system.

APPENDIX 6B
DAIRY OPERATION BEST MANAGEMENT PRACTICES PROGRAM
STANDARD BEST MANAGEMENT PRACTICES

WATER USE CATEGORY 5. DUST CONTROL, CALF HOUSING CLEANING AND FEED APRON FLUSHING **Description:** Control of dust, wastes and feed residues is necessary for fly control, sanitation and animal health. This requires water for cleaning and flushing feed aprons and calf housing and for wetting roadways. Conservation potential in this category includes recycling and reusing water, avoiding waste, and employing simple technologies that can reduce the amount of water needed for dust control.	
BMP 5.1	If the dairy flushes the cow feed apron, design the systems to recycle water from the cow udder wash system or to pump wastewater and recycle it from the lagoon or wetland area. The Annual Report required by A.R.S. § 45-632 shall include a description of how water is recycled at the operation, an estimate of the amount of water recycled, and the method of estimation. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to how water is recycled.
BMP 5.2	If the calf housing utilizes a flush system to remove animal wastes, design and manage the system so that it uses only the minimum amount necessary and equip with a timer to minimize the duration of each flush. The Annual Report required by A.R.S. § 45-632 shall include a description of how the system is designed and managed to minimize water use, the length of time of each flush and the number of times per day on average that the system is in operation, and a water system map of the facility showing the location of the timer. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the design or operation of the flush system.
BMP 5.3	If dust control practices are used at the facility, the following dust control methods should be used: paving, aggregate, chemical binding agents or dairy wastewater if consistent with state and federal standards. If potable water is used for dust control it must be used as efficiently as possible. The Annual Report required by A.R.S. § 45-632 shall include a description of the dust control technology(ies) used and the area on which dust control is practiced, and the amount of water used for dust control. If water use is estimated, provide a description of how water use is estimated. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to dust control practices.

APPENDIX 6B
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WATER USE CATEGORY 6. DAIRY ANIMAL COOLING

Description: Dairy animal cooling is an effective method to improve milk production per cow and reproductive efficiency, which are important factors in dairy profitability. Animal cooling is also an important factor in improving animal health. The amount of water required depends on the type of method or methods used to cool cows, on the maintenance practices for the system and on the hours of usage. Methods to conserve water for each cooling system are available to dairy farm management.

6.1	**HOLDING PEN COOLING**
BMP 6.1.1	Design and operate independent fan and spray systems to ensure that water is used efficiently under all weather conditions. The Annual Report required by A.R.S. § 45-632 shall include a diagram demonstrating that fans and spray systems are used independently and provide information on how the system is managed depending on weather conditions. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change to the fan and spray systems.
6.2	**COW EXIT AND RETURN LANES COOLING**
BMP 6.2.1	Use leaf gate, wand switch, electric eye or motion (proximity) indicators to automatically activate the water valve. The Annual Report required by A.R.S. § 45-632 shall include a description of the activation device used at the dairy operation and how it operates, including the length of time the water valve is in operation and the amount of water used, and include the average number of times per day that the device is activated in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in activation device.
6.3	**FEED LINE COOLING**
BMP 6.3.1	Locate the feed line cooling system to take advantage of prevailing winds in order to place water directly on the dairy animal. Equip the system with timers to control the duration of use. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all timers and the direction of prevailing winds. Report the length of time the timer is in operation and the average number of times per day that the system is in operation in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the feed line cooling system or timers.

6.4	**CORRAL SHADE COOLERS**
BMP 6.4.1	Equip corral shade coolers with thermostats or timers to control operation time. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the dairy facility showing the location of all thermostats or timers and report the average daily length of time the coolers are in operation in a year. This information shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the thermostats or timers.
BMP 6.4.2	Establish an inspection schedule to ensure regular maintenance of nozzles and water filter systems. The Annual Report required by A.R.S. § 45-632 shall include an inspection and maintenance schedule. This schedule shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the maintenance schedule.
WATER USE CATEGORY 7. DAIRY ANIMAL FEED PREPARATION **Description:** Water is used in the preparation of dairy animal feed at dairy operations to pre-soak cereal grain for processing, (rolling and flaking). A large use of water in feed preparation is its addition to the total mixed ration to improve feed intake. The amount of water needed depends on the dryness of the feed in the ration. The total amount of water added to the feed could equal 20 percent of the ration. The greatest conservation potential for feed preparation rests with leak detection and prevention.	
BMP 7.1	Install shut-off valves at each water source used for feed preparation to allow for the isolation of leaks. If a leak occurs, isolate the area of the leak and/or repair the leak within 72 hours. The Annual Report required by A.R.S. § 45-632 shall include a water system map of the facility showing the location of all valves. This map shall be submitted one time only (the first annual report following acceptance into the BMP Program) unless there is a change in the location of the valves.